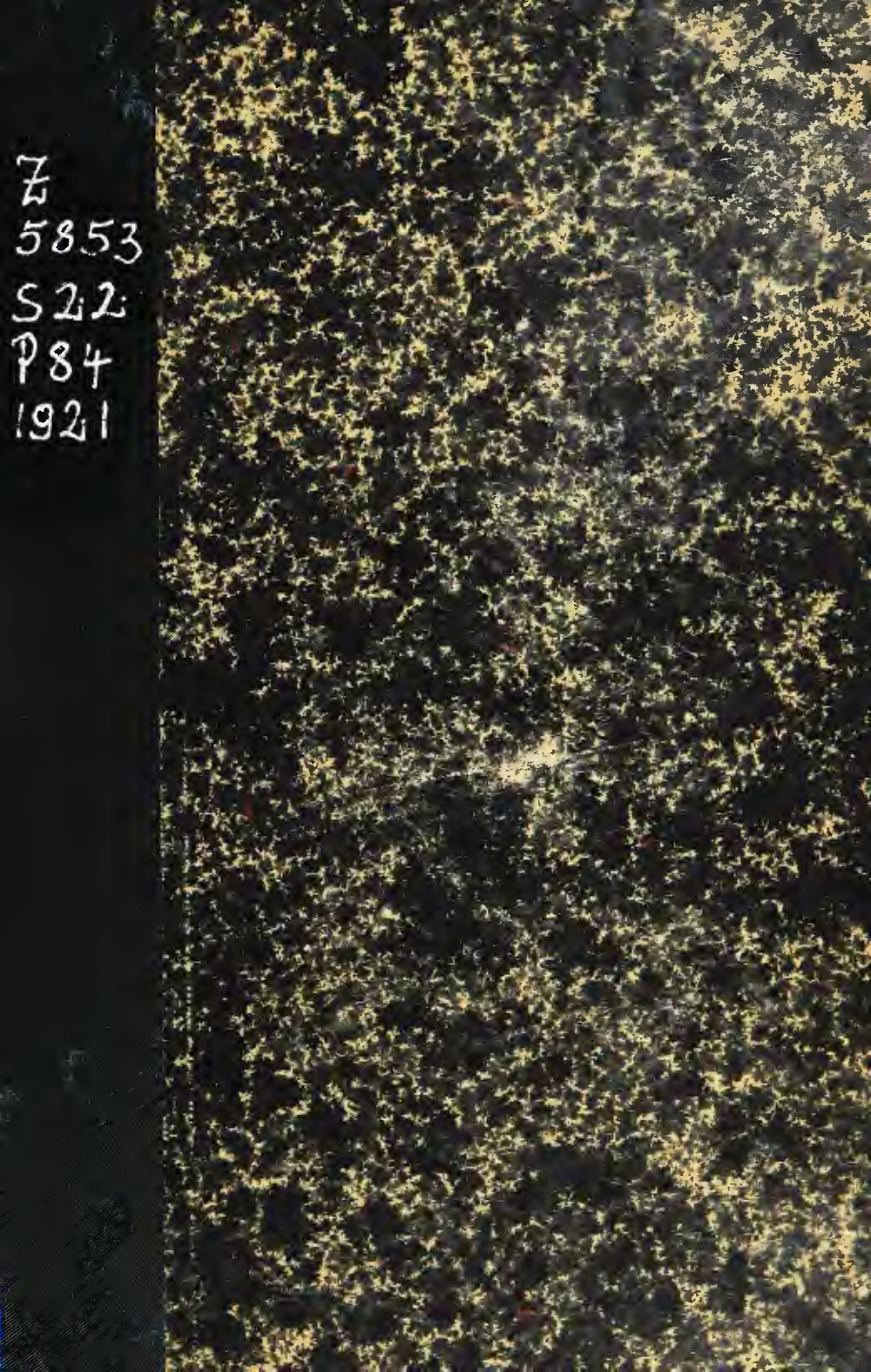

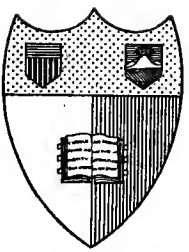

The Activated Sludge Process of Sewage Treatment

A Bibliography of the Subject

With Brief Abstracts, Patents, News Items, Etc.,
Compiled Mainly from Current Literature.
Second Edition, 1921

FILTROS

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FOREWORD

IN compiling this bibliography, an attempt has been made to arrange the matter in chronological order. The first periodical reference for each abstract is supposed to indicate the first appearance of the article in print, though not necessarily the full paper, as proceedings, transactions, annual reports, etc., which contain it are often issued many months later. The subsequent periodical references under the same abstract may be either the original article, a reprint or an abstract of it. Publications appearing monthly are credited with issue on the first of the month, annual reports, transactions, etc., are placed at the end of the year in which the document is dated. The periodical index at the end gives the date of publication corresponding to the volume and page number.

While there are doubtless some omissions, an effort has been made to make this revision of the bibliography complete from the beginning to the end of 1920, the compiler not attempting to define "the beginning" of the activated sludge process proper, further than to insert as the first reference the earliest article relating to the subject which has come to his attention. At all events it is believed that the compilation will be found useful to Sanitary Engineers and others interested in sewage disposal.

Indebtedness is acknowledged to Prof. Edward Bartow, Professor of Chemistry and Head of the Department of Chemistry, State University of Iowa; to Dr. F. W. Mohlman, Chief Chemist for the Chicago Sanitary District, and to Mr. T. Chalkley Hatton, Chief Engineer, Milwaukee Sewerage Commission, for valuable assistance given.

January, 1921.

NOMENCLATURE CONCERNING THE ACTIVATED SLUDGE PROCESS OF SEWAGE DISPOSAL AS SUGGESTED BY F. A. DALLYN, GEO. T. HAMMOND AND T. CHALKLEY HATTON, A COMMITTEE APPOINTED FOR SUCH PURPOSE AT AN INFORMAL MEETING OF MEMBERS OF THE AM. SOC. C. E. AND OTHERS INTERESTED IN SEWAGE DISPOSAL, HELD AT PITTSBURGH, JUNE, 1916.

(Revised December, 1920)

DEFINITIONS

1. **Activated sludge treatment** may be defined as a biochemical process by which the purification of sewage is accomplished by passing it through tanks, in which sewage sludge is artificially agitated and intimately mixed with sewage and is supplied with the requisite oxygen for the optimum development of countless numbers of nitrifying organisms incorporated in and adhering to the sludge, the final settlement of which causes a distinct clarification of the oxidized sewage.

2. **Activated sludge** may be defined as a flocculent sludge of medium brown color enveloped by masses of aerobic organisms possessing the power of rapidly oxidizing and nitrifying sewage, and which, though of low specific gravity, settles rapidly.

3. **The process** may be divided into the following treatments:—

(a) Economic screening.

(b) Preliminary rapid sedimentation in properly designed grit chambers where combined flow of sewage and storm water must be treated. It being quite essential to prevent detritus of heavy specific gravity, such as sand and gravel, from reaching the treatments which follow.

(c) Thorough mixing in aerating the sewage with activated sludge, which may be effected by means of air, by mechanical mixers, or a combination of both. In any case sufficient air for oxidation must be applied to the admixture.

(d) Sedimentation of the sludge contained in the admixture as it passes from the aerating tank. This may be accomplished by either horizontal or vertical flow sedimentation tanks.

(e) The return of a portion of the settled activated sludge to the raw sewage before, or at the time, it enters the aerating tank.

(f) Reaerating the sludge which is returned to the raw sewage in separate aerating tanks. This may or may not be necessary, depending upon the character of the sewage treated and effluent required.

(g) Secondary sedimentation for partially dewatering the separated sludge not returned to the raw sewage.

(h) Sludge disposal. This may be effected in several ways. Where the climatic conditions are favorable, it may be dried in beds or lagoons in the open air or under cover, and the residue used for filling in low ground, or for fertilizer, or burned. Under unfavorable climatic conditions it may be pressed or centrifuged and burned, or dried by artificial heat and the residue used as fertilizer.

The terms used in connection with the process may be defined as follows:

4. Screening. Such as may be the most economical under the existing conditions. Probably through from one-eighth to one-sixteenth inch screen.

5. Grit. That portion of the mineral solids carried in the sewage liquor which will settle out under a velocity of one foot per second. The grit chamber should be so designed, and the removal of the grit so performed, that a fairly uniform velocity through the chamber may be maintained. Probably from 0.75 to 1.25 feet per second. Grit in the aerating tank seriously affects the process.

6. Air. To be obtained by means of a low pressure compressor or blower, and must be kept free of oil, grease or dust. The latter may be removed effectively by means of a standard type of air washer.

(a) Volume of air used should be expressed as "Air Factor," obtained by multiplying the volume-of-free-air-per-volume-of-sewage-treated by the feet-of-air-submergence, or the cubic-feet-of-air-per-gallon-of-sewage by the pounds-of-pressure.

(b) Area of air diffusers, where porous plates are used, to be expressed as a ratio between effective square feet of air diffusers and square feet of water surface in tank. Where grills or grids of pipes are used, size of pipe, size and spacing of perforations, spacing of pipes and grids, to be expressed in feet and inches. Feet-of-air-submergence should be noted in this connection.

(c) Time of aeration of raw sewage should be expressed in hours and minutes, computed from the average period required for the mixture of sewage and activated sludge to pass through the aerating tank.

(d) Where the activated sludge is reaerated after removal from the sedimentation tank, and before being returned to aerating tank, the air used for this purpose should be separately measured and expressed in cubic feet of air per gallon of sewage treated and added to the volume of air used in the aerating tanks to determine the full quantity of air used in the process, assuming air is used for reaerating at same pressure as for aerating.

(e) Where the sludge deposited in the sedimentation tank is removed by an air lift, the quantity used should be separately measured and expressed in cubic feet of free air per gallon of sewage treated. Pressure being considered.

(f) Power used.

7. Activated sludge. Must be of such a flocculent character as to absorb the colloidal matter in raw sewage within a contact period of two hours, and be of a golden brown color.

(a) It is to be introduced into the raw sewage as it passes into the aerating tanks, the air effecting the mixing as both pass through the tanks, in such proportions as may be necessary to secure the required effluent in each case. Probably from 15% to 25%.

(b) The proportion of the admixture shall be expressed in percentage of volume determined by settlement for one-half hour in a graduated one-liter glass cylinder approximately fifteen inches in height and two and one-quarter inches in diameter. It is also recommended that such percentage be determined as parts per million of total dry solids where facilities for making such determinations are available.

(c) The volume of sludge removed and recovered by the process should be expressed in pounds per million gallons of sewage treated, based upon the weight of the sludge free from moisture. It is also handy to express the sludge removed in gallons per million gallons of sewage treated, noting the percentage of moisture in the sludge.

8. **Sedimentation.** This may be accomplished in either of two ways:—Upward or horizontal flow. If upward flow is used the velocity should be expressed in feet per hour. If horizontal flow, express the velocity in feet per minute. Average velocities being used. Probably the most certain method of expressing rate of sedimentation is by gallons of sewage passing through per square foot of tank surface.

(a) The ratio between the area of sedimentation tank and aerating tank should be stated; also the ratio of the volumes of the two.

9. **Effluent.** Character of effluent should be expressed in plain biological chemical and physical terms.

(a) Biologically, in total bacteria per c. c, growing for 48 hours in nutrient agar at 20° C., and percentage of removal. Also bacteria at 37° C.

(b) Chemically, in oxygen consumed, dissolved oxygen, organic nitrogen and free ammonia as determined by the standard methods recommended by the American Public Health Association. Stability in hours with methylene blue without dilution at 70° F.

(c) Physically, in suspended matter in parts per million and in percentage of removal from raw sewage. Clarification in terms of turbidity determined by the standard methods recommended by the American Public Health Association.

10. Capacity.

(a) Capacity for areation should be expressed in gallons per acre of tank surface per 24 hours, stating effective depth of tanks and average contact period.

(b) Capacity for sedimentation should be expressed in gallons per square foot of tank surface per 24 hours, stating effective depth of tank.

11. Costs. To be expressed in million gallons of sewage treated and divided as follows:—

(a) Population served.

(b) Character of sewage, whether purely domestic, or domestic and manufacturing, or combined with storm water.

(c) Total volume of sewage treated per year.

(d) Average daily volume of sewage treated, with low and peak rates.

(e) Average daily suspended matters in raw sewage.

(f) High, low and average temperatures of sewage and atmosphere.

(g) Method of sludge disposal.

(h) Pounds of sludge produced per year on dry basis.

(i) Pounds of sludge produced (on dry basis) per million gallons treated (average).

(j) Cost of sludge disposal per dry ton produced, including overheads.

(k) Cost of sludge disposal per million gallons of sewage treated, including overheads.

(l) Cost of sewage treatment, including sludge disposal per million gallons of sewage treated, including overheads.

(m) Total cost of plant and when built.

(n) Fixed annual charges, including interest and depreciation.

(o) Total operating charges including ordinary repairs.

(p) Total cost of sewage treatment, including overhead and fixed charges, per million gallons of sewage treated.

Note:—Where possible, operating charges should be subdivided into cost of air furnished, plant labor, sludge disposal labor, and other charges in connection with disposing of sludge.

F. A. DALLYN,
GEORGE T. HAMMOND,
T. CHALKLEY HATTON,
Committee.

ABSTRACT BIBLIOGRAPHY

1912

1 **Experiments upon the purification of sewage and water at the Lawrence Experiment Station.** H. W. CLARK and S. DEM. GAGE. *44th Annual Report State Board of Health of Mass.* 1912. 275-367. In the sub-chapter on the aeration of sewage as an aid to filtration (pp. 290-2), it is noted that the aeration of sewage perceptibly clarified it, and that when green growths occurred in the aerated sewage, it became saturated with 0. These observations led to a series of experiments begun in April, 1912, to test the efficiency of aeration combined with these growths, in which three small sand filters were used; the first receiving raw sewage; the second, sewage aerated for twenty-four hours by drawing or blowing air through it and the third containing aerated sewage with green growths. It was found, after the experiments had been under way for several months, that nitrification was occurring in the aerated sewage containing the growths, over 1.5 parts of nitrate per 100,000 being found. Later an aerating tank containing slabs of slate was put into operation, in which it was observd that the slate and sides of the tank became covered with a compact brown growth, and that this growth collected not only the suspended matters, but also a large portion of the colloids, so that after a few hours treatment the sewage became free from both. Tables of analytical data showing free and albuminoid ammonia, nitrates, nitrites, and 0 consumed in the raw and treated sewage are given.

1913

2 **Preliminary note on the bacterial clarification of sewage.** G. J. FOWLER and E. M. MUMFORD. *Jour. Royal Sanit. Inst.* 34, 497-500. *Surveyor* 44, 287-8. *Chem. Abst.* 7, 3632. Laboratory experiments on quantities up to 4 liters indicate the possibility of removing the colloidal matter from sewage by adding 1 grain of iron salt per gallon, inoculating with the iron bacterium "M7" (*) and passing air through the liquid for 6 hours. A precipitate of ferric hydrate is obtained which settles out in 6 hours leaving a clear, colorless liquid. The coarser suspended matter must first be removed.

*(Further reference to the iron bacterium "M7" can be found in *Jour. Chem. Soc.* 103, 645-50. *Jour. Royal Sanit. Inst.* Nov., 1913. *Surveyor* 42, 497; 45, 504-6. *Can. Engr.* 26, 598-60. *Chem. Abst.* 7, 2770; 8, 2016. See also Book "Iron Bacteria"; D. Ellis, pp. 179, Metheun & Co., Lt'd., London. 1919.)

3 **Aeration of sewage and other foul liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 22,952, Oct. 11, 1913. *Jour. Soc. Chem. Ind.* 34, 244. *Chem. Abst.* 9, 831. A series of diffusers spaced apart and each formed of a porous earthenware plate, on the under side of which compressed air is admitted, are arranged transversely across the bottom of each section of the tank holding the sewage to be aerated. The sewage is transferred from one section of the tank to the next by a circulator consisting of an uptake pipe at the bottom of which compressed air is admitted; the mixture of air and sewage rises and is delivered onto the covered top of a downtake pipe, into which air is also admitted below the water level. The lower end of the downtake pipe is enlarged to form a foot chamber, where the excess of air escapes and is passed on to supply the diffusers, while the sewage passes into the bottom of the next section of the tank. (Cf. U. S. Patent 1,247,540. Ref. No. 341.)

4 **Work of the Lawrence Experiment Station for 1913—The Purification of sewage and water and investigations on allied subjects.** H. W. CLARK and S. DE M. GAGE. *45th Annual Report State Board of Health of Mass.* 265-368. Respecting the aeration of sewage, the studies begun in 1912 were continued with various modifications and a new aerating tank put into operation on Jan. 2nd. Aerating periods varying from 24 to 5 hours, and air volumes ranging from 200,000 to 25,000 cu. ft. per hour per million gallons of sewage were tried, the results of the various changes in the methods of operating producing far less differences in the efficiency of the process than might be expected. The effect of the gelatinous growths in reducing the Kjeldahl N was clearly established, as was also the clarifying effect of aerating with sludge. Effluent stability was more pronounced when the sewage was aerated 10 hours or more. A brief historical review of sewage aeration work is given, as well as several tables of analytical data.

1914

5 **Purification of sewage or other impure waters.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 729, Jan. 10, 1914. *Jour. Soc. Chem. Ind.* 34, 197. *Chem. Abst.* 9, 1814. The sewage is purified in presence of air and cultivated sludge in an annular tank. Transverse depressions are formed in the floor of the tank at intervals and in each depression a plate is suspended so that the circulating sewage has to pass underneath the plate in each depression. Circulation is brought about by admitting compressed air at the bottom of each depression in such a way as to mix with the sewage on one side of the plate only. The upper part of the plate is so formed as to deflect the rising current horizontally towards the next depression.

6 **Sewage treatment by aeration and contact in tanks containing layers of slate.** H. W. CLARK and G. O. ADAMS. *Eng. Record* 69, 158-9. *Chem. Abst.* 8, 1319. Sewage treated with air in tanks with vertical slate walls one inch apart, gave 87% removal of suspended matter with 5 hours aeration.

7 **Experimental plant for treating sewage at Brooklyn, N. Y.** G. T. HAMMOND. *Munic. Jour.* 36, 233-9. *Munic. Eng'rg.* 47, 427-36. Equipment includes various tanks and apparatus for the investigation of sewage treatment by forced aeration. Plant not operating long enough to justify publishing results.

8 **The present position of the sewage disposal problem.** G. J. FOWLER. *Surveyor* 45, 504-6. *Engineer* 117, 272. *Wasser u. Abwasser* 8, 417-8. *Trans. Liverpool Engr. Soc.* 35, 213-23. *Sanit. Record* 53, 294. *Expt. Sta. Record* 32, 88. The sanitary aspects of sewage disposal are discussed with reference to conditions permitting use of the sludge as fertilizer. The author anticipates the time when it will be possible to purify sewage completely in a tank, with production of inoffensive sludge which can be disposed of as fertilizer. The forced aeration experiments at Lawrence, Mass., and those in progress at Davyhulme (Manchester, Eng.) are referred to.

9 **Experiments on the oxidation of sewage without the aid of filters, I.** E. ARDERN and W. T. LOCKETT. *Jour. Soc. Chem. Ind.* 33, 523-39. *Surveyor* 45, 610. *Chem. Abst.* 8, 2207. *Expt. Sta. Record* 32, 387. The solid matter obtained by prolonged aeration of sewage—which for reference purposes and the want of a better name has been designated "activated sludge"—has the power of enormously increasing the purification of sewage by simple aeration, its effect depending upon intimate contact with, and its proportion in the raw sewage. Unoxidized solids should not be allowed to accumulate. Temperature exerts considerable influence. Laboratory experiments indicate that purification of average strength Manchester sewage can be accomplished in 6 to 9 hours, using 25% sludge. DR. J. GROSSMANN, F. R. O'SHAUGHNESSY, S. E. MELLING, P. GAUNT, J. T. THOMPSON and DR. G. J. FOWLER participated in the discussion, covering mainly the composition of the sludge, operating

costs and possible revenues from the process. Several tables of analytical data are given.

10 **Apparatus for the purification of sewage and analagous liquids.** W. JONES and JONES & ATTWOOD, LT'D., Amblecote, Worcestershire, Eng. British Patent 19,915, April 11, 1914. *Jour. Soc. Chem. Ind.* **33**, 1170. *Chem. Abst.* **10**, 655. A pipe, reaching nearly to the bottom of a tank containing the sewage, extends over a partition to the bottom of a second tank; compressed air is delivered into the end of the pipe in the first tank, thus causing a mixture of liquid and air to pass over into the second tank; the lower end of the pipe in this tank has a perforated chamber which distributes the air into the liqud. A supplementary volume of air is introduced into the descending pipe in the second tank.

11 **Apparatus for the purification of sewage and analogous liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 19,916, April 11, 1914. *Jour. Soc. Chem. Ind.* **34**, 632. *Chem. Abst.* **10**, 655. In an aerating tank for the treatment of sewage, the floor of the tank is divided into a number of saucer-like depressions, in the center of which is a porous plate. Compressed air is admitted to chambers below the porous plates, and fine bubbles rise from their upper surface; currents of liquid upwards over the porous plates and downwards between the depressions are thus produced, carrying with them the suspended solids and bacteria. The bottom of the tank being curved or inclined downwards to the diffusers from points between the same, cause the deposited solids falling to the bottom of the tank between the diffusers to pass under the influence of the air currents from the latter. The sewage is admitted at the bottom of one end of the tank and flows over a wall at the other end. After aeration is completed, the liquid is allowed to stand till clear, when the clarified liquid is run off and the solids allowed to remain. Fresh sewage is then admitted at once and the aeration recommenced. (Cf. U. S. Patent 1,282,587, Ref. No. 428.)

12 **Sewage purification by aeration: Manchester experiments.** EDITORIAL. *Surveyor* **46**, 113-4. Experimental results promising. Costs still in doubt. Tank capacity should be 1.5 times dry weather flow, based on 12 hour period. Preliminary calculations, from meager data, give approximately 1 cu. ft. of air per gallon of sewage. Cautions with regard to cost of such large volumes of air.

13 **Apparatus for purifying sewage.** G. W. & J. F. NAYLOR, Denby Dale, Yorks, Eng. British Patent 20,259, Sept. 28, 1914. *Jour. Soc. Chem. Ind.* **34**, 814. *Chem. Abst.* **10**, 655. A tank has a false bottom of porous tiles, so supported that the air space below each row of tiles is separate from the adjoining air space. Air under pressure is admitted through horizontal pipes laid below each row of tiles. The tiles may be supported directly on the floor of the tank or may fit in trays. The air pipes may support the trays or the tiles, or may have short upright branches supporting them. The pipes and branches have perforations for the passage of the air to the under side of the tiles.

14 **Apparatus for purifying sewage.** G. W. & J. F. NAYLOR, Denby Dale, Yorks, Eng. British Patent 20,579, Oct. 6, 1914. *Jour. Soc. Chem. Ind.* **34**, 978. *Chem. Abst.* **10**, 945. In the purification of sewage by aeration in a tank with a false bottom of porous material, the false bottom is made of a pliable material, such as filter-cloth, felt, canvas, or perforated metal, supported if desired on wire netting, through which the air supply diffuses into the sewage in the tank. The porous floor may be laid on the air pipes placed horizontally along the bottom of the tank, or on the framework covering each line of pipes and dividing the air space into separate compartments. The floor may also be supported on boxes with porous sides, the air pipes coming through the bottom of the tank and being in a vertical position in the center of each box.

15 **Purification of sewage and analogous liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 21,976, Nov. 4, 1914. *Jour. Soc. Chem. Ind.* 35, 272. *Chem. Abst.* 10, 1068. Active bacterial sludge is prepared by forcing air in small bubbles through raw sewage, keeping the latter in circulation. After a time the sludge is allowed to deposit, the liquid run off, a fresh quantity of sewage run in, and the process repeated. Sufficient active sludge is prepared to fill the treatment tank one-fifth to one-third full. The tank is then filled up with raw sewage. The tank is formed of one or more long endless channels of rectangular form, the bottom of the tank sloping to one end. The dividing wall between the two portions of the channel has vertical slits in it so as to permit the free passage of sludge and water and the maintenance of level throughout the channel. Air is supplied in small bubbles transversely across the channel at several points, and just in front of these points a baffle plate is hung. In this way the rising mixture of air and sewage causes a current of sewage under the baffle, and the current is kept up throughout the channel, inducing a continuous circulation of the sewage. Aeration is conducted for one to five hours and then stopped for one or two hours, the clear liquid then drawn off down to as low a level as desired, and the tank then filled up with fresh sewage. The sludge formed from each charge is drawn off from time to time. Closed tanks may also be used, the air liberated at the surface of the first channel being led to the bottom of the adjoining one and so on, the last channel being open or the air led away by a shaft. The pressure of the air over the liquid may also be used for emptying the channels. When the sewage is below 46° F. (8° C.) it is warmed to this temperature in order that nitrification of the sludge may not be hindered. Aerating sewage in the presence of humus obtained from filter beds is also claimed. The aeration is carried out by forcing air through porous bodies, such as porous earthenware, textile fabrics, cocoanut fiber or lead wool. A suitable apparatus is shown.

16 **Means of and methods for treating sewage.** W. M. BECKETT, Manchester, Eng. British Patent 21,985, Nov. 4, 1914. *Jour. Soc. Chem. Ind.* 34, 1269. *Chem. Abst.* 10, 1068. The sewage enters a closed tank having a floor pervious to air. Compressed air rising through the floor agitates and aerates the sewage and sludge, and the gases given off are passed with the air to a destructor or other combustion furnace. The purified liquid is discharged from the tank by a floating arm, down to a certain level, below which the sludge is allowed to collect, a portion being run out from time to time. Porous tiles, perforated pipes, etc., may be used for the pervious floor.

17 **Purification of sewage and analogous liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 22,736, Nov. 19, 1914. *Jour. Soc. Chem. Ind.* 35, 195. *Chem. Abst.* 10, 1241. Sewage is admitted gradually to a tank containing a residuum of activated sludge from a preceding operation, and air is blown through it from the bottom of the tank at the same time, the operation taking one to six hours. When the tank is full aeration is stopped, the sewage allowed to remain quiescent for one or two hours, the clear liquid being then drawn off from the top down to the level of the sludge layer in about half an hour. If through any cause the sludge should get less active, it may be drawn off into side tanks for aeration, and afterwards returned to the main tank. Cultures of organisms may be added to the tank to assist in the purification process. Several tanks may be worked in combination, in which case the valves for supplying air and sewage and for discharging the liquid are operated in sequence by automatic means, such as float valves, or a water-clock, or other time-piece operating pneumatic or electrical devices, so that the operation is continuous. (Cf. U. S. Patent 1,247,543, Ref. No. 344.)

18 **Purification of sewage and analogous liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 22,737, Nov. 19, 1914. *Jour. Soc. Chem. Ind.* 35, 195. *Chem. Abst.* 10, 1241. A tank of continuous

channel form with semi-circular ends is used, the space enclosed by the inner wall of the channel forming an inner tank. Air diffusers are placed along the bottom of the tank, and just behind these, baffle plates are let down from the surface. The mixture of sewage and air passes under the bottom and rises up the side of the baffle, and thus produces a forward movement of the sewage along the tank. A weir leads from one part of the channel into the inner tank, and some distance in front of this weir the introduction of air is stopped, so that there is time for some sedimentation of the sludge to take place before the sewage passes into the inner tank, which constitutes a settling tank and from the upper part of which the purified sewage is continuously drawn off. The sludge deposited in the inner tank is lifted back by an air-lift into the treatment tank. An annular treatment tank or one in the form of a zig-zag channel may also be used. (Cf. U. S. Patent 1,247,542, Ref. No. 343.)

19 **The complete bacterial treatment of sewage without filters.** W. NAYLOR. *Surveyor* 46, 592-4. *Chem. Abst.* 9, 229. In discussion of the paper by ARDERN and LOCKETT, (Ref. No. 9), mention is made of isolated instances of purification without filters on sewage farms where the sewage was allowed to stand in pools. This purification required considerable time. It is noted that one volume of sludge to 4 or 5 of sewage used in the experiments of A. and L. is almost too solid to deal with, as ordinary precipitation methods give one part of sludge to 110 of sewage and require 6 hours for settling. The air used for aerating may require after-treatment on account of odors taken up from the sewage. Sludge disposal should be made easier because the material is non-putrescent and it should be pressed more easily, as it would be less slimy than ordinary sludge.

20 **Tank for the purification of sewage.** G. W. & J. F. NAYLOR, Denby Dale, Yorks, Eng. British Patent 23,146, Nov. 27, 1914. *Jour. Soc. Chem .Ind.* 34, 1269. *Chem. Abst.* 10, 1389. The tank has a level floor and is divided into several compartments by baffle plates reaching from the top nearly to the bottom, and which may be inclined in the direction of the flow of sewage. Porous tiles are fitted in the floor behind each baffle plate and air is forced through the tiles. Air may also be blown over the surface of the sewage by pipes attached to the top of the baffle plates. The circulation of the sewage is assisted by the upward current of air and the sludge is kept in suspension. The exit pipe of the tank is provided with a float discharge, arranged to empty three-fourths of the contents, leaving the remainder to activate the succeeding supply of sewage. The baffle plates may also be arranged to reach the bottom of the tank, and pipes provided passing through each plate. The tank may be divided longitudinally into two sections to economize space.

21 **Sewage treatment by aeration.** EDITORIAL. *Surveyor* 46, 674. Comment on paper by W. H. DUCKWORTH. (Ref. No. 22). Caution recommended with regard to cost data.

22 **Aeration experiments with activated sludge.** W. H. DUCKWORTH. *Surveyor* 46, 681-2. *Chem. Abst.* 9, 679. Experiments at the Salford sewage works showed successful treatment of sewage by the process of ARDERN and LOCKETT. In tanks of 34,500 gallons capacity with 25% sludge, 75,000 gallons could be treated in 21 hours. One hour to fill, 3 hours of aerating, 2 hours to settle and one hour to empty; 7 hours for complete treatment of one tankfull. Purification was 90% on the oxygen absorption and 76% on the albuminoid ammonia. The sludge contained only half the fat of ordinary sewage sludge, while the phosphoric acid was twice and the nitrogen about 3 times the amount in ordinary sludge. As the experiments were made with apparatus at hand, and in connection with the regular work of the plant, no accurate cost figures could be given.

23 **Oxidation of sewage without the aid of filters, II.** E. ARDERN and W. T. LOCKETT. *Jour. Soc. Chem. Ind.* 33, 1122-4. *Chem. Abst.* 9, 679. *Expt.*

Sta. Record 34, 888. Continuous flow experiments with a tank of 35 gallons capacity were satisfactory though the tank was not designed for best results. Perforated pipes distributed the air. Sludge was re-aerated. Fill and draw experiments in 50 gallon casks, using porous tiles for air diffusers also gave satisfactory results, 4 hours aeration with 25% sludge showing a purification measured by the oxygen absorption of 92%. 15 cu. ft. of air per hour per sq. ft. of tank area was used. Diffused air made unnecessary the re-aeration of the sludge, as well as giving a much better effluent than that obtained by perforated pipes. Comparative results are given in tabular form. Experience shows the necessity for adequate scientific control. Experiments using a tank of 20,000 gallons capacity, 400 sq. ft. area, are being made. This should handle 60,000 gallons of sewage daily.

24 **The purification of Salford sewage along the lines of the Manchester experiments.** S. E. MELLING. *Jour. Soc. Chem. Ind.* 33, 1124-30. *Chem. Abst.* 9, 679. Refers to the same work as described under reference 22. It is an established fact that it is possible to clarify and purify crude sewage in bulk in 3 hours, the effluent produced satisfying any local or international standard. Several tables of analytical data accompany the article. In the discussion, MR. J. P. WAKEFORD referred to the promising tests of the activated sludge process at Wakefield, Eng., (Cf. Ref. No. 63), where various trade wastes were encountered. The dry sludge there contained 43.99% organic matter, 56.01% mineral water; total N, 4.59%, phosphates, 2.74%, iron, 9.67%. The possibility of the iron acting as a catalyst in flocculating the colloids was suggested. MR. W. H. DUCKWORTH stated that 80,000 gallons per day were being treated at Salford on the fill and draw plan. A 12,000 gallon continuous flow tank is contemplated. Some difficulty had been experienced through the stopping up of the holes in the perforated pipes. DR. G. J. FOWLER said that the idea which started these particular researches really originated at Lawrence, Mass. In his opinion, the iron bacterium "M7" probably played some part in the process. MR. J. H. LESTER, MR. W. THOMPSON, DR. J. GROSSMANN and DR. E. ARDERN also participated in the discussion, the latter emphasizing the importance of complete admixture and intimate contact of the activated sludge with the sewage, describing as useful for this purpose, a specially prepared porous tile air diffuser.

25 **Sewage treatment by aeration.** EDITORIAL. *Surveyor* 46, 701. Analogy drawn between the Lawrence, Mass. slate tank experiments and ARDERN and LOCKETT'S experiments. Filters become choked and the amount of air supplied cannot be controlled as in the activated sludge process. Cost data again asked for.

26 **A recent development of the sewage problem.** E. ARDERN. *Surveyor* 46, 714-7. *Sanitary Record* 54, 401, 413; 55, 5-6. *Chem. Abst.* 9, 679. A report of the bottle and cask experiments at Davyhulme, Manchester, (Ref. No. 9) and a summary of the Salford work. (Ref. Nos. 22, 24.) Grit should be removed. Proportions of sludge to sewage should be 1 to 4. Purification is seriously diminished below 10 C., and trade wastes may have inhibitory action. Costs discussed briefly.

27 **Purification of sewage.** G. W. & J. F. NAYLOR. Denby Dale, Yorks, Eng. British Patent 24,386, Dec. 21, 1914. *Jour. Soc. Chem. Ind.* 35, 195. *Chem. Abst.* 10, 1567. A tank is divided into compartments by vertical baffles and is provided with an air supply from tubes entering the pipes by which the sewage flowing over the baffles is led to the lower portion of the next compartment. In an alternative form, air is supplied to rows of boxes with perforated or permeable faces fixed to one or each side of the baffles; the boxes may be arranged checker-wise, with the permeable faces delivering horizontally; or obliquely overlapping, with inclined permeable faces alternately directed upwards and downwards. Agitators may be used to mix the sludge at the bottom of the tank with the incoming sewage, and may also deliver air into the sewage.

28 **Apparatus for the purification of sewage and analogous liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 24,630, Dec. 24, 1914. *Jour. Soc. Chem. Ind.* 35, 195. *Chem. Abst.* 10, 1686. A tank has a discharge pipe practically flush with the bottom, and over the pipe, and fitting on it, is a superposed series of rings or cylinders reaching above the surface of the liquid in the tank, all the joints being water-tight. When all the rings are in position the series forms a closed tube. Each ring is connected with the one below it by sliding links which permit of the rings being lifted in succession from the top and which leave a considerable space between the lifted ring and the one below it. As each ring is lifted, liquid flows into the mouth of the next lower ring, and in this way the tank is emptied in successive layers from the surface. The rings are lifted by means of a pulley chain connected with a bucket which is filled from a cistern through a regulated tap, the cistern being filled with liquid from the tank by a pipe near the surface with a regulating tap. When all the rings have been lifted a percussion valve in the bottom of the pulley bucket is opened automatically and the bucket emptied; the empty bucket being raised again by the rings in the tank subsiding into their places. In an alternative form of the apparatus, part of the discharge end of the tank is formed of wooden slats working in grooves, the top slat being connected at each end to a pair of pulley chains and lifting those below it by links, the discharge in this case taking place through the end of the tank. The pulley bucket works inside of the tank. Another method of effecting the discharge is by a float carrying a siphon discharge pipe which empties into the tank discharge pipe, the float being counterbalanced by a weight acting over a pulley. The short legs of the siphon are trapped by cups just below the surface of the liquid. Sludge is discharged from the tank when desired, by valves in the bottom. The discharge apparatus may be arranged to open and close the sewage inlet valves of the tank and to actuate the air supply valve.

29 **A recent development of the sewage problem.** DISCUSSION. *Surveyor* 46, 754. In the discussion of the paper by E. ARDERN (Ref. No. 26), DR. G. J. FOWLER describes how previous work led up to activated sludge experiments. W. H. DUCKWORTH discusses the Salford work. DR. ARDERN claims the sludge is granular and can be handled easily by simple straining filters. Hopes that the length of the accumulation period may be cut down.

30 **Experiments upon the purification of sewage and water at the Lawrence experiment station during the year 1914.** H. W. CLARK and G. O. ADAMS. *46th Annual Report Mass. State Dept. Health.* 295-346. *Chem. Abst.* 11, 177. *Expt. Sta. Record* 35, 887. In the chapter on the purification of sewage by aeration and growths, (pp 301-9) are reports on the aerating tank put into operation in January, 1913, and of three others which were started to determine the effect of this treatment on raw, settled, and septic sewage. The effect of aeration in a secondary tank was also studied. Calculated on capacity, all of these tanks contained 5 to 15% of slate. Air was supplied through jets in the tank bottom, with deflecting baffles to cause circulation of the sewage. With a 5 hour aeration period, and air supplied at the rate of 25,000 and 50,000 cu. ft. per hour per million gallons of sewage, all the effluents were well clarified and 20 to 50% of the samples taken were stable. 5 hours re-aeration increased the proportion to 90%. Tabulated analytical data showing free and albuminoid ammonia, organic and inorganic N, O consumed, and bacterial removal are given.

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31 **Sewage treatment by aeration.** G. B. KERSHAW. *Surveyor* 47, 8. The treatment of storm water, up to three times the dry weather flow, will be expensive. Refers to the Brooklyn aeration experiments where the cost of air was considered high with 2 hours aeration.

32 **Sanitary engineering in 1914. The activated sludge system.** ANON. *Engineer* 119, 32. A brief outline of the activated sludge process is

given, with particular reference to the production of the active sludge. The bearing of the organism "M7" on the process is considered, as are the experiments of DR. FOWLER, ARDERN & LOCKETT, W. H. DUCKWORTH, S. E. MELLING, and J. P. WAKEFORD.

33 **Purification of sewage and other liquids.** W. JONES and JONES & ATTWOOD, LT'D., Stourbridge, Eng. British Patent 1,141, Jan. 23, 1915. *Jour. Soc. Chem. Ind.* 35, 326. *Chem. Abst.* 10, 2017. Air is supplied to the sewage mixed with the sludge, not uniformly as is usual, but intermittently, or in varying volumes or at varying pressures, or both, during the period of aeration. By employing a relatively small volume of air over a long period, the aeration of the sewage may be effected, and by increasing the volume or pressure for a short period, the sludge and sewage are thoroughly mixed. In this way a smaller quantity of air is used than for a uniform supply. An automatic valvular apparatus is provided which consists of a bucket-wheel in a tank of water, to which compressed air is supplied, causing the wheel to rotate. The spindle of the wheel carries a cam which operates a valve in piston form in connection with an air chest; when the piston is raised air passes from the chest to a pipe leading to a main air valve which it actuates. The valve passes compressed air either directly to the diffusing pipes in the sewage tank, in which case a pulsating effect is produced in the sewage, or first to an air receiver which after being filled is allowed to empty into the diffusing pipes, in which case a gradually decreasng volume of air is supplied to the sewage. Other methods of varying the air supply are also described. (Cf. U. S. Patent 1,247,541, Ref. No. 342 and Can. Patent 183,586, Ref. No. 402.)

34 **Apparatus for introducing gases into intimate contact with liquid sewage.** G. W. MOTTRAM, Deepcar, Yorks, Eng. British Patent 2,421, Feb. 16, 1915. *Jour. Soc. Chem. Ind.* 35, 434. In a vertical cylindrical sewage tank, the apparatus takes the form of a vertical rotating shaft carrying a pair of arms at its lower end. The shaft is hollow and compressed air is supplied through it to the arms, which are made of perforated pipes or of plain metal pipes carrying earthenware pipes. These earthenware pipes are arranged concentrically around the metal pipes and spaced from them by distance pieces to provide an air passage. The earthenware pipe is porous preferably along one section of its length only. In a rectangular tank the air diffusing pipes are supported at each end on wheels running along rails on the bottom of the tank, or are suspended from arms supported on wheels on rails on the top of the walls of the tank. The air supply is brought by flexible piping to one of the supporting arms which takes it to the air diffusing pipes. (Cf. U. S. Patent 1,195,067, Ref. No. 177.)

35 **Observations on some European water purification plants and sewage disposal works.** E. BARTOW. *Jour. Am. Waterworks Assoc.* 2, 213-24. *Chem. Abst.* 9, 1521. *Univ. Ill. Bull.* 13, 162-72. (Water Survey Series No. 12, 1915.) Reference is made to the experiments on the aeration of sewage in the presence of activated sludge in progress at Manchester, Eng., and to similar work which is being carried on by the Water Survey Station at the Univ. of Ill. at Urbana.

36 **English experiments on sewage aeration revived as preliminary to the Baltimore tests.** L. C. FRANK. *Eng. Record* 71, 288-9. *Chem. Abst.* 9, 1645. Enumerates some features of the activated sludge process at Manchester and Salford as described by ARDERN and LOCKETT, and others. (Ref. Nos. 9, 22, 23, 24.) A continuous flow tank will supercede the fill and draw methods.

37 **Treatment of sewage.** C. H. COOPER, Wimbleton, Surrey, Eng. British Patent 3,831, March 10, 1915. *Jour. Soc. Chem. Ind.* 35, 326. *Chem. Abst.* 10, 2116. A portion of sewage which has been activated is mixed with raw sewage in an enlargement of the mouth of a vertical pipe up which the raw

sewage is conveyed . The mixture passes out through a nozzle in the side of the enlargement and below the surface of the sewage; at the same time compressed air is blown through the nozzle with the sewage mixture. In this way the sewage mixture is atomized as it leaves the nozzle, and afterwards is mixed further with air drawn in through louvres against the lower sides of which the atomized sewage impinges.

38 **The purification of sewage by aeration.** R. O. WYNNE-ROBERTS. *Can. Engr.* 28, 335-6. *Contract Record* 29, 647-9. *Chem. Abst.* 9, 1210. The aeration of sewage is reviewed, particularly the work of CLARK and GAGE at Lawrence, Mass., and that of FOWLER and MUMFORD, in which the iron bacterium played a part. The activated sludge work of ARDERN and LOCKETT at the Davyhulme works, Manchester, Eng., DR. E. BARTOW at Urbana, DUCKWORTH and MELLING at Salford, and of J. P. WAKEFORD at Wakefield are also noted and some of their results given, including cost estimates. The proposed activated sludge experiments at Milwaukee, Baltimore and Regina, Sask., Canada, the latter in some detail, are also referred to.

39 **Apparatus for introducing gases into intimate contact with liquids.** G. W. MOTTRAM, Sheffield, Eng. British Patent 4,240, March 18, 1915. *Jour. Soc. Chem. Ind.* 35, 521. The gas is passed into a pipe of porous material or a conduit formed of porous tiles or blocks immersed in the liquid. The porous tubes, tiles or blocks are formed of coarse materials, and are provided with a surface facing of much finer material, so that while the gas passes easily through the coarser layers, it is very finely divided by the finer material before it comes in contact with the liquid.

40 **Sewage aeration at Lawrence and Manchester compared.** H. W. CLARK. *Eng. Record* 71, 367-8. *Chem. Abst.* 9, 1521. Mr. Clark states that the heavy, brownish gray, gelatinous and other growths upon the slate beds at Lawrence which clarify the circulating sewage are probably the same bodies as those developed by FOWLER and ARDERN & LOCKETT in the Manchester tank and called "activated sludge."

41 **Can sewage sludge be made valuable as a fertilizer?** EDITORIAL. *Eng. News* 73, 593. *Expt. Sta. Record* 33, 423. Refers to a paper presented by DR. E. BARTOW and to a sample of dried activated sludge exhibited by him at the meeting of the Lake Mich. Water Com. held at Milwaukee on March 19, 1915. Sample contained 6% N in a form available for plant food, and the estimated value of the sludge in N, P, and K compounds was $15 to $20 per ton.

42 **Sewage aeration experiments in the United States.** EDITORIAL. *Surveyor* 47, 449. Refers to the continuous flow activated sludge experiments to be started by the U. S. Public Health Service at Baltimore, Md., using a modified Imhoff tank.

43 **Purification of sewage by aeration in the presence of activated sludge.** E. BARTOW and F. W. MOHLMAN. *Jour. Ind. Eng. Chem.* 7, 318-20. *Eng. News* 73, 647-8. *Eng. Record* 71, 421-2. *Eng. & Contg.* 43, 310-1. *Munic. Jour.* 38, 504-5. *Jour. Soc. Chem. Ind.* 34, 508. *Surveyor* 47, 642. *Chem. Abst.* 9, 1521. *Expt. Sta. Record* 33, 423, 786; 38, 490. *Univ. Ill. Bull.* 14, 325-35. (Water Survey Series No. 13.) Experiments at Urbana, Ill., with fresh sewage of domestic origin, showed that nitrate was formed in 15 days by blowing 4830 cu. ft. of air. By siphoning off the supernatant liquid and refilling, sludge was accumulated. On the 31st treatment 3 cu. ft. of air per gallon of sewage was required in 5 hours. Nitrification was complete. One hour aeration seemed practically sufficient. Worm life was active. (*Aeolosoma hemprichi*). The sludge contained on a dry basis, 6.3% N, 4.0% fat, 1.44% phosphoric acid and 75% volatile matter.

44 **The Milwaukee, Wis., sewage tests.** NEWS ITEM. *Eng. News.* 73, 650. Briefly reviews the methods tried and states that "large scale studies of activated sludge are to be made under the direction of DR. GILBERT J. FOWLER of Manchester, Eng."

45 **An exceptionally promising method of sewage treatment.** EDITORIAL. *Eng. & Contg.* 43, 306. Commenting on the work of BARTOW and MOHLMAN, (Ref. No. 43), it is noted that their activated sludge experiments indicate a stable effluent, a commercially valuable residual sludge, and that the process is free from nuisance. The cost question is of chief consideration, though the effects of low temperatures, amount of air necessary, and flexibility of the process are points yet to be cleared up.

46 **Activated sludge in sewage oxidation.** EDITORIAL. *Munic. Jour.* 38, 509. Refers to English experiments; discusses the question of practicability; the possible necessity of keeping the air at certain temperatures; and expresses the hope that some way may be found to operate continuous flow tanks rather than the intermittent type.

47 **Co-operation sought in conducting activated sludge experiments at Baltimore.**—L. C. FRANK and C. W. HENDRICK. *Eng. Record* 71, 521-2. *Chem. Abst.* 9, 1521. Discussion of design and operation of continuous flow aero tanks is accompanied by request for suggestions and criticisms.

48 **Process of purifying sewage or other wastes, and apparatus therefor.** L. C. FRANK, Washington, D. C. U. S. Patent 1,139,024, May 11, 1915. (Application filed April 2, 1915. 10 claims.) *Off. Gaz.* 214, 498. *Jour. Soc. Chem. Ind.* 34, 680. *Chem. Abst.* 9, 1647. Purifying sewage by agitating and oxidizing a flowing stream at one point in its path by injection of jets of air, allowing the sediment to settle at another point in the path of flow, and returning the sediment to the point of oxidation for further treatment. The sewage is led down by a pipe to the bottom of a central chamber of the tank and flows upwards. Air is admitted, also, at the bottom, and oxidizes the sewage which overflows at the top of the chamber into two V-shaped side chambers where settling takes place; the deposited solids fall through openings at the bottom of the side chambers into the central chamber, while the clear liquid passes to the effluent channel. (This patent dedicated to the public.)

49 **Aeration method of purifying sewage.** J. P. WAKEFORD. *Inst. Munic. and County Engrs.* June, 1915. *Can. Engr.* 29, 249-51. *Chem. Abst.* 9, 2785. Experiments on activated sludge are described. Barrel and bottle tests showed complete oxidation of the ammonia by aeration for two hours. A porous tile diffuser was used. In a large tank holding 11,000 gallons exclusive of 25% sludge, operated on the fill and draw plan, a cycle of half-hour fill, two hours blow, two hours settlement and half-hour empty, worked well. 90 cu. ft. of air per minute was used under a pressure of 5 lbs. per sq. in. The sludge contained 4.59% nitrogen. Analyses of sludge and sewage are given.

50 **Activated sludge experiments at Baltimore.** L. C. FRANK and C. W. HENDRICK. *Surveyor* 47, 693. *Chem. Abst.* 9, 2786. Continuous flow necessary for economical operation. Oxidation promoted by fineness of bubbles. Aeration may be effected by (a) impact of inflowing sewage, (b) aeration, (c) mechanical devices. Sludge must be returned from settling to aeration tank.

51 **Fertilizers.** G. J. FOWLER and G. MUMFORD. British Patent 8,397, June 7, 1915. *Jour. Soc. Chem. Ind.* 35, 1074. *Chem. Abst.* 10, 2948. A fertilizer is produced by sterilizing any form of sewage sludge by heat and restoring bacterial activity by the addition of fresh active residue or sludge produced by the aeration of sewage or like liqiud in the presence of bacteria. The temperature of sterilization is preferably not higher than the boiling point of water, and the proportion of the active sludge added is from 5 to 10%

of the bulk. In a modification, the fertilizer is produced by a partial sterilization of the active residue or sludge at a temperature of about 60° or 70° C. (Cf. Danish Patent 22,389, Ref. No. 309: U. S. Patent 1,294,080, Ref. No. 454: Can. Patent 189,921, Ref. No. 467.)

52 **Treatment of sewage sludge.** ANON. *Trans. Can. Soc. C. E.* 28, part 2. *Can. Engr.* 28, 697-9. A discussion of P. GILLESPIE's paper by R. O. WYNNE-ROBERTS in which the activated sludge experiments of DR. FOWLER and ARDERN & LOCKETT at Manchester, Eng., and of W. H. DUCKWORTH at Salford are briefly described.

53 **Activated sludge and the Baltimore experiments.** W. S. COULTER. *Eng. Record* 71, 784. In a letter to the editor a continuous flow activated sludge tank is suggested, which comprises an aerating and settling tank, the latter having a hopper bottom with very steep sides, communicating through a bottom outlet with a chamber from which the deposited sludge can be raised and delivered as desired by an air lift.

54 **Activated sludge experiments in Canada.** R. O. WYNNE-ROBERTS. *Can. Engr.* 29, 112. *Munic. Eng'rg.* 49, 68-9. *Surveyor* 48, 211. *Chem. Abst.* 9, 2787. Refers to experiments at Regina, Can., in which two galvanized-iron tanks 4 ft. 7.5 in. diam., by 24 ft. deep, with glass windows in the side were used. About 577 gallons of sewage was treated in each tank, that in tank one by straight blowing, perforated pipes distributing the air, while in the other tank aeration was produced by injecting air by means of a centrifugal pump. The air was intended to be supplied at the rate of 15 cu. ft. per sq. ft. of tank area per hour, but was not closely controlled in the second tank. Absence of objectionable odors were noted, but no results or conclusions are given.

55 **Activated sludge and the Baltimore sewage experiments.** G. J. REQUARDT. *Eng. Record.* 72, 23. In a letter to the editor Mr. Requardt refers to the use of converted Imhoff tanks for activated sludge experiments and suggests that better oxidation may be obtained by having the flow perpendicular to the direction of the agitating air bubbles. Sketch of a suggested horizontal continuous flow tank is also included.

56 **Tanks for the purification of sewage.** G. W. & J. F. NAYLOR. British Patent 9,870, July 7, 1915. *Jour. Soc. Chem. Ind.* 35, 615. In tanks for the purification of sewage wherein air is forced through porous tiles, the latter are arranged at the bottom of the tank in continuous rows, curves or circles, in such a manner as to enclose areas which are available for the deposition of the sludge.

57 **Purification of sewage.** G. W. & J. F. NAYLOR. Denby Dale, Yorks, Eng. British Patent 9,989, July 9, 1915. *Jour. Soc. Chem. Ind.* 35, 434. A tank is used with a porous floor under which pipes are laid for diffusing air through the floor to aerate the sewage. The floor of the tank is divided into sections, either zones, quadrants, parallel strips or squares. The pipes under the floor are placed parallel or crossing each other, and have alternate perforated and blank lengths, so as to supply air to alternate sections of the floor. The air is supplied under a low pressure through valves controlled by a clockwork arrangement which is worked so as to supply air to the various sections alternately or in any desired combination.

58 **Activated sludge experiments at Milwaukee, Wis.** T. C. HATTON. *Eng. News,* 74, 134-7. *Surveyor* 48, 258-61. *Chem Abst.* 9, 2412. Tests of the activated sludge method of sewage treatment are described. A large fill and draw tank, a continuous flow tank of the same size, and two small tanks provided with glass windows are included in the studies being made. Methods of air diffusion, volume and time of air application, and cost records are given.

59 **The sludge problem: standards for effluents recommended by the Royal Commission on Sewage Disposal, and sewage purification by aeration in the presence of activated sludge.** H. M. WILSON. *Surveyor* 48, 74-6. *Chem. Abst.* 10, 793. A short account of the development of the activated sludge method and the results of its use leads to the conclusion that the process produces satisfactory purification, but the cost of operation has not yet been fully worked out.

60 **Activated sludge in America.** W. N. BAKER. *Eng. News* 74, 164-71. *Chem. Abst.* 9, 2412. *Exp. Sta. Record* 34, 332. Notes on the new process of sewage treatment gathered by Mr. Baker on visits to several experimental plants. Sewage is aerated in the presence of an accumulation of aerated sludge. There is reason to hope that a high degree of clarification—and perhaps bacterial reduction when necessary—with a stable effluent and a quick drying sludge, high in fertilizing value, can be produced by this process.

61 **Brooklyn sewage aeration and activated sludge experiments.** E. J. FORT. *Eng. News* 74, 214-7. *Chem. Abst.* 9, 2682. Studies have been made of sewage aeration by compressed air passed upwards from a pipe grid and shallow gravel bed through sewage passing downwards, in a deep tank containing 9 horizontal disk deflectors. The first experiments with plain aeration of the sewage in this tank were not very encouraging, an air supply of 0.75 volume per volume of sewage with two hours retention, being insufficient to produce any marked improvement on crude sewage. The second experiment was carried out in an aerated contact bed. The improvement was very marked, the 24 hour samples being almost of drinking water quality. The third experiment dealt with the activated sludge process and was carried out in the same tank as the first experiment. The continuous flow and fill and draw plan was tried alternatively. 24 hours aeration resulted in 100% relative stability.

62 **Sewage purification by forced aeration.** EDITORIAL. *Surveyor* 48, 129. Comment on paper by J. P. WAKEFORD. (Ref. No. 63.) High moisture content of sludge is undesirable. Odors and costs questioned. Careful control necessary. J. D. WATSON'S caution against trade wastes cited, also E. B. MARTIN'S remark that he was unable to find a satisfactory air diffuser at Salford.

63 **Brief notes of experiments in sewage purification by forced aeration.** J. P. WAKEFORD. *Surveyor* 48, 132-3. *Can. Engr.* 29, 429. *Chem. Abst.* 10, 793. *Expt. Sta. Record* 34, 488. At Wakefield, Eng., experiments were carried out in a tank 30 by 12 by 6.5 ft. on the fill and draw plan, allowing 0.5 hour for filling, 2 hours for blowing, 2 hours for settling and 0.5 hour for emptying. Results were satisfactory, but several engineering difficulties must be overcome before the process can be worked on a large scale. When this is done it is safe to assume that the treatment will be less offensive, more rapid, will require less area, and be less expensive to maintain than present processes, on account of the omission of chemicals, greater fertilizing value of the sludge, and less expense for attendance.

64 **The activated sludge process.** EDITORIAL. *Can. Engr.* 29, 239. Refers to articles by ARDERN & LOCKETT, (Ref. Nos. 9 and 23), and by S. E. MELLING (Ref. No. 24) on the Manchester and Salford work, and notes that experiments are under way in several places in the United States and Canada, with concordant results in general considering the variety of the experiments. The Canadian authorities can be depended upon to take an important part in these investigations. The principles of the process are discussed.

65 **Experiments in sewage purification by forced aeration.** DISCUSSION. *Surveyor* 48, 143-6. Discussion of J. P. WAKEFORD'S paper. (Ref. No. 63.) Large tank volumes considered necessary. J. D. WATSON criticises complexity

of the process and is sceptical regarding its practicability. E. B. MARTIN discusses undesirability of tarry matters in sewage and the difficulties in handling variations in flow. A. T. GOOSEMAN, R. BROWN, E. H. CRUMP, C. H. COOPER and E. J. SILCOCK also participated in the discussion.

66 **Activated sludge sewage treatment.** EDITORIAL. *Munic. Jour.* **39**, 257. Refers to the several experimental plants in the United States and to the encouraging results obtained. Discusses the plant at Milwaukee and concludes that the process promises extremely well, though many practical points are yet to be studied.

67 **Experiments on separate digestion of activated sludge needed.** W. L. STEVENSON. *Eng. Record* **72**, 238. In a letter to the editor, the author suggests the desirability of experimentation on the separate digestion of activated sludge in order to obtain a sludge of less bulk, and freedom from odor.

68 **Sewage disposal by aeration.** EDITORIAL. *Surveyor* **48**, 253. The results of experiments on sewage aeration are inconclusive as yet. The most difficult questions to be settled are, the best method of air diffusion and the adoption of the process to the continuous method of treatment. Varying the depth of the tanks, or properly baffling the tank to obtain maximum contact with the air, may be a solution of the first question.

69 **Activated sludge progress at Cleveland.** R. W. PRATT. *Eng. News* **74**, 571. *Chem. Abst.* **9**, 2957. A unit to handle one million gallons of sewage is to be built. The experimental tank gave good results with 3 hours aeration and 10 to 15 minutes' sedimentation.

70 **Milwaukee's activated sludge plant; the pioneer large-scale installation.** T. C. HATTON. *Eng. News* **74**, 667-8. *Eng. Record* **72**, 481-4. *Surveyor* **48**, 564-7. *Engineer* **121**, 58-9. *Chem. Abst.* **10**, 77. The plant consists of 11 circular reinforced concrete tanks, 30 ft. inside diam. by 13 ft. max. depth. Tanks 1 to 8 inclusive are the aerating tanks in which the sewage mixed with activated sludge is aerated. Tank 9 is used as the sedimentation tank and tanks 10 and 11 are the activated sludge tanks. Drawings are given showing the curved baffles and the manner of sloping the bottom of the running-through channels of the aerating tanks. The sewage enters tank 1 and is aerated with the sludge, then passes to tank 2 and is again aerated, and so on through the other tanks to tank 9, where it is settled. The sludge from this tank is discharged by gravity into tanks 10 and 11, where it is aerated to maintain the nitrogen cycle. From these tanks the sludge is pumped to the inlet chamber of tank 1. Activated sludge which is in excess of that needed is dried and used for fertilizer. The plant is designed to treat 1,600,000 gallons of sewage per day with a four-hour period of aeration and with 25% activated sludge. It is estimated that the cost will be $5.30 per million gallons, exclusive of engine room and plant labor, and the cost of disposal of the sludge.

71 **Oxidation of sewage without the aid of filters, III.** E. ARDERN and W. T. LOCKETT. *Jour. Soc. Chem. Ind.* **34**, 937-43. *Surveyor* **48**, 450-4. *Chem. Abst.* **10**, 502, 794. *Expt. Sta. Record* **34**, 888. Manchester sewage was aerated in 50-gal. casks, but not to complete nitrification. In 4 weeks enough sludge was obtained to give satisfactory results with 8 hours aeration. Data as to amount of sludge produced were not conclusive. Mineral precipitates were added to the sludge, but no advantage ensued; a deflocculating action was frequently observed. Experiments in gallon bottles indicate that the volume of air necessary may be as low as 6 cu. ft. per hour per sq. ft. of tank area. The best proportion of sludge to sewage is given as 2:3 for Manchester sewage. Estimated cost of air per million gal. of sewage: Min. $1.98, Max. $4.92, with electricity at one cent per kw. hour.

72 **American Sewerage Practice.** METCALF & EDDY. (*Book*) Vol. III, First Edition, 1915. pp. 222, 386-94. A brief general review of the activated sludge process is given, with mention of the work done at Lawrence, Milwaukee, Ill. State Water Survey at Urbana, and Manchester, Eng.

73 **Activated sludge progress at Houston, Texas.** ANON. *Eng. News* 74, 717. *Can. Engr.* 29, 503. *Chem Abst.* 10, 240. In a communication from the city engineer, Mr. E. E. SANDS, statement is made that a 14,000 gallon tank has just begun operating and is expected to be running normal in a few weeks. The small 12 in. square, 8 ft. deep tank is also operating.

74 **Purification of sewage by the utilization of activated sludge.** E. LONG, Manchester, Eng. British Patent 14,733, Oct. 19, 1915. *Jour. Soc. Chem. Ind.* 35, 1129. *Chem. Abst.* 11, 1229. Screened sewage is passed downward through a pipe containing a form of injector nozzle, and means are provided for admitting air to this part of the pipe, or compressed air may be introduced. The mixture of sewage and air passes into a widened portion of the pipe which contains a rotary agitator, and thence through a rotary pump into the bottom of a tank. A pipe connects the top of the tank with the pipe above the injector nozzle, and the apparatus may be worked so as to circulate the contents of the tank until a sludge is obtained so altered in character as to justify the term "activated sludge." The apparatus may also be employed for circulating a mixture of activated sludge and sewage or waste water.

75 **The world's first full-scale plant for the treatment of sewage by the activated sludge process.** T. C. HATTON. *Eng. & Contg.* 44, 322-7. *Can. Engr.* 29, 517-9, 549-50. *Proc. Am. Soc. Munic. Improv.* 22, (1915). *Engineer* 121, 58-9. *Chem. Abst.* 10, 78. Tests on the plant at Milwaukee are described, showing bacteria removals of 99% and cost data indicating a partial cost of $4.43 per million gallons of sewage when 1.77 cu. ft. of air per gallon are used. A stable effluent is produced with city sewage containing 250 p.p.m. of suspended matter. The sludge contained 5.45% of ammonia.

76 **Has the activated sludge process of sewage treatment made good?** EDITORIAL. *Eng. & Contg.* 44, 322. Commenting on the work at Milwaukee, it is noted that the activated sludge process is exceedingly flexible, free from nuisance, and provides a high degree of bacterial removal and clarification. Winter conditions of operating are yet to be studied.

77 **Sewage treatment by aeration.** EDITORIAL. *Surveyor* 48, 445. Continuous flow desirable. Air costs not so great as thought at first. Investigation of effect of tanks of various depths is urged.

78 **Choosing air compressors for activated sludge tanks.** C. H. NORDELL. *Eng. News* 74, 904-6. *Chem. Abst.* 10, 238. Reciprocating and hydraulic air compressors, turbo-blowers, and positive pressure blowers are discussed. Positive pressure blowers are useful in small installations while turbo-blowers are best for large plants.

79 **Sewage treatment and the war.** EDITORIAL. *Eng. News* 74, 899. Comments on the passing of the Royal Commission on Sewage Disposal and the improbability of Imhoff tank installations in England for some time, suggesting that when the war is over there may be some surprising realignment of sewage treatment and that the activated sludge process, if its possibilities and economies are then shown, may find its way to all parts of the world.

80 **British Engineer submits an activated sludge query.** O. J. WILKINSON. *Eng. News* 74, 948. *Chem. Abst.* 10, 238. Attention is called to the similarity of sprinkling filters and activated sludge, in that both depend upon the passage of sewage in thin films over active sludge. Grit should be removed. Uniform contact and distribution are requisite. The cost is not yet definitely known.

81 **Activated sludge at Milwaukee, Wis.** ANON. *Munic. Jour.* 39, 776. Recent information concerning tests being made. Effect of low temperatures. Plant for continuous operation. Results and cost of treatment.

82 **Activated sludge and the Baltimore sewage experiments.** O. J. WILKINSON. *Eng. Record* 72, 640. In a letter to the editor Mr. Wilkinson refers to his experience with the activated sludge process and to proposals for tanks of various designs, the general difficulty being to keep the particles of activated sludge uniformly distributed and at the same time in intimate contact with the whole of the flow, without excessive use of air.

83 **Recent results of experiments on the purification of sewage by aeration in the presence of activated sludge, at the University of Illinois.** E. BARTOW and F. W. MOHLMAN. *Eng. & Contg.* 44, 433-4. *Eng. News* 74, 1096-7, *Jour. Ind. Eng. Chem.* 8, 15. *Jour. Soc. Chem. Ind.* 35, 555. *Chem. Abst.* 10, 362. *Expt. Sta. Record* 34, 591. *Univ. Ill. Bull.* 14, 325-35. (Water Survey Series No. 13.) A test plant of 4 tanks, each 3 ft. 2 in. square by 8 ft. 5 in. deep, has been operated on domestic sewage on the fill and draw plan. The sludge was accumulated on a 6-hour cycle. Results show that one sq. ft. of filtros in 10 sq. ft. tank area is not sufficient, but that 3 in 10 gives the best results. About one cu. ft. of air per gallon of sewage was used, though more was required for strong sewage. The free ammonia and presence of nitrates was used as indicators.

84 **The fertilizer value of activated sludge.** E. BARTOW AND W. D. HATFIELD. *Eng. & Contg.* 44, 434-6. *Jour. Ind. Eng. Chem.* 8, 17-20. *Jour. Soc. Chem. Ind.* 35, 552. *Am. City* 14, 282-5. *Chem. Abst.* 10, 365. Pot studies and gardening experiments show that the N in activated sludge is in a very available form and that this sludge is a valuable fertilizer, being comparable with dried blood. (Cf. Ref. No's. 118 and 444.)

85 **The treatment of sewage by aeration in the presence of activated sludge.** E. BARTOW. *Metal. & Chem. Eng'rg.* 13, 901-4. *Trans. Am. Inst. Chem. Eng.* 8, 119-29: (1915). *Chem. Abst.* 10, 794. *Expt. Sta. Record* 34, 591; 37, 87. Status of the activated sludge process of sewage treatment in America, with details of the work done at the State Water Survey station, Univ. of Illinois, Urbana, Ill. (Cf. Ref. No. 83.)

86 **Activated sludge plants for packinghouse wastes.** NEWS ITEM. *Eng. News*, 74, 1101. Experimental activated sludge plants are being built in Chicago by SULZBERGER & SONS CO. and by ARMOUR & CO. It is stated that at a recent conference of engineers and chemists representing the Chicago packinghouse interests, much enthusiasm was shown for the activated sludge process, and that some even went so far as to declare that it was the only process of sewage treatment brought to their attention which gives promise of satisfactorily treating the liquid wastes from the packinghouses, and at the same time recovering the valuable material which they contain.

87 **Sewage disposal by aeration.** EDITORIAL. *Surveyor* 48, 562. Comment on the Milwaukee experiments. (Ref. No. 70.) Questions if tanks are deep enough. Cost data very interesting.

88 **A year of activated sludge.** W. T. CARPENTER. *Annual Report N. J. Sanit. Assoc.* (1915). Following a brief historical review of the process, the Brooklyn experiments on the fill and draw plan are described. For this work a 16,000 gallon tank was used, perforated pipes diffusing the air at the rate of about 1.17 volumes per volume of sewage per hour. The experiments on the continuous flow plan utilized a tank of 4 ft. diam. by 8 ft. deep of about 900 gallons capacity, the air being diffused through carborundum discs. Both experiments were promising from a chemical and bacteriological standpoint. The work of DR. BARTOW at Urbana, Ill., and of MR. T. C.

HATTON at Milwaukee is referred to, the advantages and disadvantages of the process being summed up in closing.

89 **A year of activated sludge at Milwaukee, Wis.** G. W. FULLER. *Eng. News* 74, 1146-7. *Surveyor* 49, 233-4. *Chem. Abst.* 10, 239. The author accepts the theory of activated sludge as correct but comments on practice. At Milwaukee 2 to 3 hours aeration removes 96 to 99% of the bacteria and nitrifies the effluent according to the amount of air used. Odors are removed; the sludge dries readily; though the process may fail through excessive or insufficient aeration or the presence of mineral grit.

90 **Activated sludge treatment for packinghouse wastes.** NEWS ITEM. *Eng. News* 74, 1148. *Chem. Abst.* 10, 238. At the Chicago stockyards ARMOUR & Co. after successful experiments with small tanks, now have an experimental plant with a tank of 20,000 gallons capacity working on the continuous flow plan with excellent results since early in Nov. 1915. MORRIS & Co. and SWIFT & Co. have plants of the same general character, and the latter is said to be building a 500,000 gallon plant. SULZBERGER & SONS Co. are reported to be experimenting with both the activated sludge and the electrolytic processes. The above are independent but relate to the investigations carried on by the Sanitary District of Chicago respecting the utility of the activated sludge process for treating the trade wastes from the stockyards. The latter is building a plant to handle 150,000 gallons of sewage daily.

91 **Activated sludge system of sewage purification.** G. J. FOWLER. *Surveyor* 48, 604. In a letter to the editor DR. FOWLER reports that JONES & ATTWOOD have installed a fill and draw plant at the Baguley Sanatorium of the Manchester Corporation, and that they have also started continuous flow experiments at Stamford and Worcester (Eng.) The latter plant is to treat 2 million g. p. d. The first tank used at Milwaukee was designed by J. & A., who claim all patent rights.

92 **Method of and apparatus for the treatment and purification of sewage.** E. B. MARTIN, Eccles, Lancastershire, Eng. British Patent 17,463, Dec. 14, 1915. *Jour. Soc. Chem. Ind.* 36, 160. The apparatus consists of a cylindrical tank divided into segments, each segment forming a treatment unit. The apparatus may be worked on the continuous flow or the quiescent system, or on a combination of both. The sewage enters any one segment where it meets with activated sludge, and the mixture is agitated by air blown in from the bottom and evenly distributed by baffle plates. The treated sewage overflows into a radial trough in which any sludge settles out and which is run back into the segment, while the liquid flows over a weir and is led into to the next segment for further treatment. One or more of the last segments is used for a settling tank before the completely purified liquid is discharged. One segment is always being emptied and cleaned in the cycle of working. The activated sludge is run out from each segment into a central well. The volume of air supplied to any segment can be varied at will by adjustable valves.

93 **The activated sludge experiments at Salford, Eng.** W. H. DUCKWORTH. *Biggs & Sons' Contractors Record* 15. (Dec. 15, 1915). *Surveyor* 48, 648-52. *Engineer* 120, 620-1. *Munic. Jour.* 40, 199-200. *Chem. Abst.* 10, 1064. Continuation of the Salford experiments (Ref. No. 24) has given satisfactory purification of sewage with 2 hours blowing of air, even in winter, and part of the time with only one hour aeration. The presence of trade wastes of a sterilizing nature at times necessitates longer periods of blowing to restore the activity of the sludge. Success, with some of the air jets clogged up, leads to the conclusion that a smaller amount of air might be used. In continuous treatment 60,000 gallons per day are treated in an aeration tank of 12,000 gallons capacity, with 4 tanks of 1,500 gallons capacity in series for recovery of sludge carried from aeration tank. From each of the first two settling

tanks, sludge is pumped back to the inlet of the aeration tank for about 5 minutes in every half-hour, while the other two require pumping back only about 2 minutes per week. Conclusions have not been reached in regard to cost of operation or disposal of excess sludge.

94 **Activated sludge is capturing the popular fancy.** EDITORIAL. *Eng. & Contg.* 44, 453. Advises engineers to stick to the old methods of sewage treatment until the activated sludge process has definitely made good. "Activated sludge will need to be active indeed if it accomplishes all that the public expects it to do."

95 **The work done at Salford by the activated sludge process.** DISCUSSION. *Surveyor* 48, 629-30. *Sanitary Record* 56, 466-7. Discussion of W. H. DUCKWORTH'S paper. (Ref. No. 93). Waste of air and utilization of oxygen considered. S. RIDEAL claims the rate of aeration is too rapid for efficient absorption of the oxygen. Costs are paramount. S. BARWISE, J. B. BARFORD, W. D. SCOTT-MONCRIEFF, W. H. MAKEPEACE, P. GAUNT and J. LAMB also participated in the discussion.

96 **Sewage purification by forced aeration.** EDITORIAL. *Sanitary Record* 56, 463-4. Comment on the salient points in W. H. DUCKWORTH'S paper. (Ref. No. 93). The paper was especially directed towards establishing the reliability of sewage purification by forced aeration, and also to indicate from results obtained in the experiments: (1) The minimum time of aeration required to obtain a satisfactory effluent. (2) Whether the method is liable to be affected by weather conditions. (3) Whether the air jets would become clogged and in what period of time. (4) The minimum amount of air necessary. (5) Whether the "continuous flow" method was possible and preferable to the "fill-and-draw" plan. (6) If the process as a whole was an economic possibility.

97 **Chicago activated sludge experiments.** NEWS ITEM. *Eng. Record* 72, 768. Activated sludge experiments will soon be carried on intensively by the Sanitary District of Chicago with the stockyards sewage, $10,000 having recently been appropriated by the trustees for that purpose.

98 **Sewage disposal by aeration.** EDITORIAL. *Surveyor* 48, 645. American results are reported more promptly than English. Air jets can be used but need frequent cleaning. Proper depth of tanks still an unknown factor.

99 **Activated sludge.** W. N. BAKER. *Sanitary Record* 56, 487-8. A survey of the activated sludge experiments conducted at various places in the United States. This method of sewage treatment involves the forced aeration of sewage in the presence of accumulated sludge, and appears to be adapted to changes of season, flood, drought, and other conditions. (Cf. Ref. No. 60).

100 **Second Annual Report of the Milwaukee Sewerage Commission.** T. C. HATTON and W. R. COPELAND. *Pamphlet* pp. 188. (Dec. 31, 1915). Data from reports of Chief Engineer HATTON and Chief Chemist COPELAND, respecting the activated sludge experiments at the Jones island sewage testing station, for the year ending Dec. 31, 1915. The experiments began in the laboratory using a glass tube 6 ft. long by 1.5 in. diam.; next, two tanks 5 ft. by 1 ft. by 10 ft. deep with glass windows in the sides were tried; then a tank 32 ft. by 10.5 ft. by 9 ft. deep on the fill and draw plan; later another tank of the same size on the continuous flow plan, this being the first continuous flow operation of the activated sludge process. The numerous experiments made with these tanks were so encouraging that a plant to handle 2 million gallons per day was decided upon. This comprised 11 circular reinforced concrete tanks 30 ft. diam.; 8 designed for aeration, 1 for sedimentation, and 2 for sludge re-aeration. The aerating tanks were so baffled that a channel 114 ft. long was provided in each, 78 filtros plates in the sloping

bottom of each channel being used as air diffusers: ratio 1 to 8.5. The settlement tank had a hopper bottom terminating in a 4 ft. diam. cast-iron pipe 24 ft. below the bottom of the tank, with an air lift for removing the sludge. The raw sewage passed through a conduit to No. 1 aerating tank, activated sludge in the desired proportion being added to it enroute, the mixture then passing through each of the 8 aerating tanks in rotation, flowing a total of 912 lineal feet. With a 4 hour aeration period, the estimated capacity of the plant was 1,620,000 gallons per day; with a 3 hour aeration period, 2,160,000 gallons per day. Different means of air diffusion, volumes of air, volumes of sludge, etc., are but a few of the great number of experiments made, the summarized results of which are shown in a mass of analytical and other data occupying about 100 pages of the report. Numerous illustrations, diagrams, and inserts of plans also accompany the report.

101 **Experiments upon the purification of sewage and water at the Lawrence Experiment station during the year 1915.** H. W. CLARK. *First Annual Report Mass. State Dept. Health.* 377-429. *Engineering* 104, 99-100. *Expt. Sta. Record* 37, 787. The sewage aeration work from 1912 to date is briefly reviewed, with particular reference to its relation to the activated sludge process. Investigations begun in 1913-14 have been continued with modifications, the results being shown in tabulated data. An activated sludge tank without slate was started early in the year and operated with 3, 5, 8, and 24 hour aeration periods. 80% of the 3-hour samples and all of the others were stable on incubation. Sludge investigations showing the increase in N and the decrease in fats, with comment on its fertilizer value are also given.

102 Worcester (Eng.) sewage works. ANON. *Pamphlet* 1915. 16 pages. Describes a visit of the water and sewerage commission to the Salford fill and draw activated sludge plant, where 80,000 gallons of sewage was being treated daily. Perforated pipes with holes at 9 inch intervals distributed the air. About 25% of sludge was carried, with the following cycle of operations:—1 hour fill, 3 hour aeration, 2 hour settlement, 1 hour emptying.

1916

103 **Activated sludge sewage treatment.** EDITORIAL. *Eng. Record* 73, 5-6. A review of the subject covering the work to date at Manchester, Eng., Milwaukee, Wis., Brooklyn, N. Y., and the Chicago stockyards. The articles of the past year contributed by DR. FOWLER, ARDERN & LOCKETT, DR. BARTOW, and MR. T. C. HATTON are discussed, the editor summing up the apparent advantages of the process as (1) the ability to control the quality of the effluent, (2) freedom from offensive odors, (3) small plant area required, (4) low first cost.

104 **Sewage disposal by the activated sludge process.** W. B. FULLER. *Am. City* 14, 78-81. A brief resume of the process with illustrations of the Brooklyn experimental plant for sewage disposal.

105 **The activated sludge method of sewage treatment.** ANON. *Munic. Engr.* 50, 6-8. A brief history of the rapid development of the activated sludge method of sewage treatment, abstracted from the results of the research of PROF. EDWARD BARTOW, of the Univ. of Illinois. It shows that there is much promise in this latest attempt to solve the great problem of the disposal of the sludge resulting from this method of sewage treatment, in part by destroying some of it in the treatment process, in part by making it innocuous and practically inoffensive, and in part by giving it some value as a fertilizer not too low in grade for practical use.

106 **Sanitary engineering in 1915. The activated sludge method of sewage disposal.** ANON. *Engineer* 121, 30-1. A general review of the activated sludge work during the year, in which reference is made to the plants at

Manchester, Eng., Salford, Eng., Milwaukee, Wis., and Cleveland, O. The 1915 articles on the subject by ARDERN & LOCKETT and by T. C. HATTON are discussed.

107 Activated sludge process at Wimbledon, (Eng.) EDITORIAL. *Surveyor* **49,** 51. Discussion of paper by C. H. COOPER. (Ref. No. 108). Doubtful about his plan of mixing aerated effluent with raw sewage, returning only a small amount of sludge, but agrees with him that it is not so much intimate contact of air with sewage as thorough mixing of activated sludge with sewage.

108 **Activated sludge.** C. H. COOPER. *Surveyor* 49, 55-6. Aeration experiments are to be undertaken at Wimbledon using atomizers. Anticipates cost of air will not exceed $5.50 per million gallons. (Imp.) Proposes to eliminate sludge, using instead the purified effluent. Statements are rather vague.

109 Brooklyn's fill-and-draw tank not a small one. W. T. CARPENTER. *Eng. Record* 73, 121. A letter to the editor to correct an impression in a recent editorial. (Ref. No. 103). The size of the tank in question being of 16,000 gallons capacity.

110 British and American patents on activated sludge. T. C. HATTON. *Eng. News* 75, 189-90. *Chem. Abst.* 10, 1064. U. S. Patent 1,139,024, issued to L. C. FRANK (Ref. No. 48) and four British patents issued to JONES & ATTWOOD, (Ref. No's. 3, 5, 10, 11), have identical process and apparatus claims. Americans have developed the continuous flow apparatus. (Cf. Ref. No. 129).

111 Sewage disposal appliances. JONES & ATWOOD, LT'D. *Surveyor* 49, 126. The first permanent activated sludge plant was installed at the Baguley Sanatorium, Manchester, Eng., being of 20,000 gallons capacity. The next plants were at Stamford and Worcester, Eng., where half the flow was first treated, then all. Worcester's total is 6 million gallons per day.

112 Pioneer activated sludge plant in service. NEWS ITEM. *Eng. Record* 73, 160. The Milwaukee plant when operating with 25% sludge in the aerating tanks and with a 4 hour running-through period, has a capacity of 1,620,000 gallons per day. The sedimentation period is 27 minutes and the velocity of flow through the 8 aerating tanks, covering 912 ft. direct travel, is 3.8 ft. per minute. Decreasing the running-through period to 3 hours increases the capacity to 2,160,000 gallons per day and the velocity to 5 ft. per minute. Costs of pumps, meters and tanks are given.

113 Purification of sewage by aeration in the presence of activated sludge. II. E. BARTOW. *Trans. Am. Inst. Chem. Engrs.* 9, 161-8. *Jour. Bact.* 1, 111. *Chem. Abst.* 10, 2115. A continuation of the experiments in the concrete tanks previously referred to, (Ref. No. 83) dealing particularly with the building up of the active sludge and the diffusion area required. The composition of the effluent air, the N in the sludge and results of pot tests with the latter as fertilizer are also given. Mechanical, chemical, and bacteriological features of the process are considered, the future of which is very bright, though much depends upon whether the sludge can be economically recovered as fertilizer material.

114 First annual report of the city engineer on sewage disposal, City of Houston, Texas. E. E. SANDS. Feb. 1, 1916. *Chem. Abst.* 10, 2015. 5,000,000 gallons of untreated sewage cause a nuisance at White Oak Bayou, one-quarter mile from the business section. Experimental work with two-story settling tanks, aerated contact beds, the electrolytic process and the

activated sludge method of sewage treatment showed the superiority of the latter method. On the fill and draw plan, 4 hours aeration with 0.437 cu. ft. of free air per gallon of sewage treated per hour, secured an average removal of 67% total organic nitrogen, 95% free ammonia, 44% total organic matter, 90% oxygen consumed, 98% dissolved oxygen consumed, 98% suspended matter and 95.8% bacteria. A continuous flow tank appeared best adapted to local conditions. A 2-unit and a 4-unit activated sludge plant have been designed. Each unit is expected to handle the sewage from 37,100 persons or an average flow of 2,190 gallons per minute. The aeration detention period of the sewage will be 1 hour 50 minutes and the sludge will be aerated for 3 hours. The tank will be supplied with 0.26 cu. ft. of free air per minute per sq. ft. of tank surface. Surplus sludge will be handled on drying beds and sold to market gardeners. The estimated construction cost is $378,000. The estimated cost for disposal is $4.20 per million gallons when the plants operate at full capacity and serve 280,000 people.

115 **Activated sludge experiments at Brooklyn, N. Y.** ANON. *Munic. Eng'rg.* **50**, 73. Refers to a paper by G. T. HAMMOND presented at a meeting of the Am. Assoc. Adv. Science in which the experiments conducted during 1915 are described. The work done does not justify a very positive conclusion, though it offers considerable promise.

116 **Success of the activated sludge process seems assured.** EDITORIAL. *Eng. & Contg.* **45**, 97-8. The critical period has been safely passed, both at Milwaukee and Urbana, these plants operating well through the cold weather. The process appears to be practical for cities having excess of 2 million gallons daily flow of sewage. Early conclusions subject to modification and many wrinkles yet to iron out.

117 **Summary and latest results on experimental work on activated sludge at Milwaukee, Wis.** T. C. HATTON. *Eng. & Contg.* **45**, 104-8. *Contract Record* **30**, 382-5. *Surveyor* **49**, 308-9. *Expt. Sta. Record* **35**, 188. A paper before the Joint Annual Convention of Ill. Section, Am. W. W. Assoc. and Ill. Soc. of Eng'rs. and Surveyors, Urbana, Ill., Jan. 27, 1916, which covers the early experiments, data on air diffusers, functions of activated sludge, effects of cold weather and volume of air, data on unit quantities, and general conclusions.

118 **The value of activated sludge as a fertilizer.** W. D. HATFIELD and E. BARTOW. *Univ. Ill. Bull.* **14**, 336-47. (Water Survey Series No. 13). *Chem. Abst.* **11**, 1711. Activated sludge was analyzed and found to contain greater quantities of N and P than other sewage sludges. The best evidence of its value was the greater growth of wheat, lettuce and radishes when the sludge was used as a fertilizer. (Cf. Ref. No's. 84 and 444.)

119 **Sewage purification by the activated sludge process.** EDITORIAL. *Surveyor* **49**, 143. Comment on paper by DR. G. J. FOWLER. (Ref. No. 120.) Draws analogy between the activated sludge process and sprinkling filters. Conservation of nitrogen an attractive feature of the activated sludge process.

120 **The activated sludge process of sewage purification.** G. J. FOWLER. *Surveyor* **49**, 148-51. *Expt. Sta. Record* **35**, 188. A summary of the present knowledge of both the scientific and practical phases of the activated sludge process of sewage purification. It has been shown by DR. BARTOW and DR. ARDERN that it is not necessary to nitrify sewage while building up sludge. Activated sludge contains no algae. Refers to American results by DR. BARTOW, T. C. HATTON, et al. JONES & ATTWOOD first developed air lifts which did not give sufficient aeration; then nozzles, which clogged; finally, porous stone diffusers, which proved satisfactory. The results being obtained in the Davyhulme and the author's laboratories indicate a possible fixation of atmospheric nitrogen. Sludge drying is a problem for the engineers. A list of 23 references to the subject is given.

121 **The activated sludge process of sewage treatment.** G. J. FOWLER. *Can. Engr.* **30**, 227-8. *Surveyor* 49, 405-6. *Jour. Bact.* **1**, 251. *Chem. Abst.* **10**, 1064. In a written discussion of the paper by RUDOLPH HERING on the "Disposal of Suspended Matter in Sewage," DR. FOWLER sketches the historical development of the activated sludge process and dwells on the effect of adding "M7" bacterial cultures in the presence of iron in solution. Much research is still required. The work of MR. HATTON at Milwaukee, and DR. BARTOW at Urbana is referred to.

122 **Activated sludge experiments at Milwaukee, Wis.** T. C. HATTON. *Eng. News* **75**, 262-3, 306-8. A number of activated sludge tanks of different designs have been operated by different methods with such promising results that a start has been made on the construction of a 100,000,000 gallon plant. Filtros was the air diffuser used in some of the tanks, the ratio of plate area to tank area being 1 to 6.6. Varied and extended studies of the activated sludge process of sewage treatment conducted during the past year are summarized and conclusions drawn as to general results and costs. With a continuous flow tank an effluent stable for 5 days, 90% reduction of suspended matter and 95% removal of bacteria at 20° C., has been obtained by using 1.75 cu. ft. of air per gallon of sewage, with a 4 hour aeration in the presence of 20% activated sludge. Basing the results upon the operation of a 50,000,000 gallon plant, the estimated cost will be $4.38 per million gallons including all overhead and boiler-room charges, but excluding engine-room and plant attendance and the disposal of the sludge. Plant construction costs are estimated at $18,000 per million gallons.

123 **News item.** *Eng. News* **75**, 293. A 150,000 gallon activated sludge plant to treat packing-house sewage was put into operation the latter part of January by the Sanitary District of Chicago, under the direction of LANGDON PEARSE, Division Eng., and DR. ARTHUR J. LEDERER, Chemist.

124 **The oxidation of sewage without the aid of filters.** E. ARDERN and W. T. LOCKETT. *Jour. Soc. Chem. Ind.* **35**, 153-5. *Chem. Abst.* **10**, 2015. Discussion of a previous paper (Ref. No. 71) in which DR. G. J. FOWLER, MR. HALLIWELL, MR. P. GAUNT and MR. W. THOMPSON participated. Mr. Ardern in response, said, among other things:—"With regard to the adoption of wire meshes as air diffusers, this was possibly a feasible proposition. It was a question of durability. Other suggestions had been the adopton of porous metal, cocoanut matting and asbestos fiber, but up to the present nothing better had been found than a porous mineral septum. Most of the tiles used up to the present in the course of the experiments under consideration, had been made of silica which was dried and burned."

125 **Sewage treatment by the activated sludge process.** HENRY TRAXLER. *Iowa Eng. Soc. Proc.* 28, 80-5. (1916). *Chem. Abst.* **11**, 509. In a brief review of the history of the process, the author states that "In this country BLACK and PHELPHS in New York; CLARK, GAGE, and ADAMS at the Mass. State Board of Health experiment station at Lawrence, were the first to obtain promising results." DR. FOWLER'S visit to Lawrence is referred to and the subsequent work of ARDERN & LOCKETT at Manchester, Eng., whose first experiments made use of 5-pint bottles. DR. BARTOW'S work at the Univ. of Ill. in 1914, and MR. T. C. HATTON'S at Milwaukee in 1915 followed. Brief considerations of the results obtained to date (Feb. 1916) are given.

126 **Air diffusers tested at Milwaukee sewage plant.** T. C. HATTON. *Eng. Record* 73, 255. *Chem. Abst.* **11**, 80. Results of experiments on activated sludge. Tabulated data obtained with open air jets, Monel metal cloth, filtros and kieselguhr are given. Filtros plates, composed of quartz sand baked, of uniform porosity, have given the most satisfactory results.

127 **Apparatus for aerating sewage and other foul liquids.** R. AMES, Brighton, Eng. British Patent 104,361, Feb. 25, 1916. *Jour. Soc. Chem. Ind.* 36, 519. The apparatus consists of a circular tank in which there is a central standpipe supporting a chamber carrying horizontal radial arms, capable of being revolved above the level of the liquid in the tank. The sewage enters by a pipe, in which it is mixed with compressed air, along the bottom of the tank to the central standpipe, from openings in the bottom of which the sewage passes into the body of the tank. Air is supplied to the chamber carrying the radial arms, and pipes depend from these arms nearly to the floor of the tank, with atomizers attached to their ends. The atomizers consist either of a metal casing containing a porous block, or layers of wire gauze, or of a hollow metal block with narrow slots. The radial arms are rotated by the pressure of the escaping air on the liquid, or by mechanical means. The purified liquid is drawn off intermittently or continuously. (Cf. Brit. pat. 110,197, Ref. No. 194).

128 **Activated sludge treatment of packinghouse wastes.** EDITORIAL. *Surveyor* 49, 234. ARMOUR & CO. have a 20,000 gallon continuous flow plant, while that of the Sanitary District of Chicago will treat 150,000 g. p. d.

129 **Is the activated sludge process of sewage treatment to be patented again?** ANON. *Eng. & Contg.* 45, 208-9. In a recent paper by MR. T. C. HATTON before the Indiana Engrs. Soc., it was stated that DR. G. J. FOWLER of England was the real discoverer of the process—if it can be considered a discovery rather than a combination of well known principles—and that his interests were turned over to JONES & ATTWOOD who secured British patents on the art. In the meantime, MR. L. C. FRANK of Washington, D. C., was granted a U. S. patent on the process covering particularly the continuous flow principle. With so much similarity between this patent and JONES & ATTWOOD'S pending applications for U. S. patents, it would appear as though the U. S. would not be warranted in granting the latter. Statement is also made that the majority of the apparatus patented in England by JONES & ATTWOOD is not essential to the proper operation of the process (Cf. Ref. No. 110).

130 **The aeration or activation of sewage.** G. T. HAMMOND. *Surveyor* 49, 255-7. A history of sewage aeration processes including BLACK and PHELPS' work at Brooklyn. Following these experiments, activated sludge tests were begun at Brooklyn in a tank of 16,000 gallon scapacity. Pipe grids with 1-16 in. holes, overlaid with 7.5 in. of broken stone served as air diffusers. Fill and draw tests with 5 hours aeration and 7 volumes of air per volume of sewage, gave a stability of 62 and nitrates 1.2 p. p. m. Next experiments were on the continuous flow plan using a tank 4.5 ft. diam. by 8 ft. deep, of about 1,000 gallons capacity, with a lower chamber for aeration and an upper one for settling, the latter occupying about 1-10 the tank. Using carborundum discs for air diffusers, air at the rate of 0.7 cu. ft. per minute, 8 hours aeration and 45 minutes settlement, the stability was low and no nitrates formed. With 4 hours aeration and 23 minutes settlement, results were unsatisfactory.

131 **The fundamental principles of the activated sludge process of sewage treatment.** T. C. HATTON. *Eng. and Contg.* 45, 235-6. *Eng. News* 75, 503. *Jour. Bact.* 1, 250. *Chem. Abst.* 10, 1064, 3122. *Ind. Sanit. and Water Supply Assoc.* 1916. In a paper before the Indiana Engineers Soc., Mr. Hatton points out that the activated sludge process should not be confused with the kind of artificial aeration of sewage, attempted from time to time in the past, which made no use of the sludge as an aid to oxidation. He thinks that the activated sludge process depends on the presence of biologic life in the sludge under aerobic conditions and that the definition given by MR. W. R. COPELAND is the best one, viz.:—"The sludge embodied in sewage and consisting of suspended organic solids, including those of a colloidal nature, when agitated with air for a sufficient period, assumes a flocculent appearance very similar to small pieces of sponge. Aerobic and facultative aerobic bacteria gather in these flocculi in immense numbers—from 12,000,000 to 14,000,000 per c. c.—

some having been strained from the sewage and others developed by natural growth. Among the latter are species which possess power to decompose organic matter, especially of an albuminoid or nitrogenous nature, setting this nitrogen free; and others, absorbing this nitrogen, convert it into nitrites and nitrates. These biological processes require time, air and favorable environment, such as suitable temperature, food supply and sufficient agitation to distribute them throughout all parts of the sewage."

132 **Report of the board of engineers on sewage disposal, to the cities of Pasadena, South Pasadena, and Alhambra, Calif.** R. V. ORBISON, C. E. HEWES and JOHN MACMILLAN. *Pamphlet*, pp. 54. (March 27, 1916.) The activated sludge process is described, and an account of the early experiments given. Sludge disposal and cost problems are discussed in connection with the possibility of a trial of the process.

133 **Some observations on the treatment of sewage by activated sludge.** W. H. DUCKWORTH. *Surveyor* 49, 352-4. *Chem. Abst.* 10, 3122. A review of results at other places and reference to the Salford experiments. Air was not measured. Jets clogged rapidly. Sludge recovered quickly from inhibitory effect of trade wastes. The author considers the activated sludge process similar to an "intensified contact bed." The Salford plant treating 55,000 g. p. d., gave satisfactory results in winter. Over-aeration is possible. As much sludge is produced as from chemical precipitation. Discussion followed in which there participated, A. R. BLEAZARD, R. J. MCKENN, W. M. JONES, ARTHUR BOWES and TOM FOGG.

134 **The activated sludge process of sewage purification.** G. J. FOWLER. *Jour. Inst. Sanit. Engrs.* 20, 29-38. DISCUSSION, (Same journal) 20, 39-49. "The activated sludge process of sewage purification may be described as a process of intensive bacterial oxidation—and would appear to consist broadly of three operations: a clotting or clarifying action; a rapid carbon oxidation process, and finally, nitrification." The scientific researches of ARDERN & LOCKETT and of DR. BARTOW and his associates are referred to, as well as the engineering developments at Davyhulme, Salford, Worcester and Stamford in England, and Milwaukee, Baltimore, Cleveland, Houston and Chicago in the United States, and Regina in Canada. Quotations from the reports of the several engineers in charge of the various plants are numerous. Of the future "Much work remains to be done on both the scientific and technical sides * * *" MR. A. P. I. COTTERELL, DR. MCGOWAN, DR. E. ARDERN, MR. G. B. KERSHAW, MR. C. SMITH and MR. H. A. ROECHLING participated in the discussion, bringing up questions of costs, effects of varying amounts of air, supervision of the process, sludge treatment and revenues therefrom, and the effects of trade wastes on the process.

135 **The latest method of sewage treatment.** E. BARTOW. *Jour. Boston Soc. C. E.* 3, 153-70. *Jour. Am. Waterworks Assoc.* 3, 327-44, 869-70. *Chem. Abst.* 10, 3122. *Expt. Sta. Record* 35, 787. Relates to the activated sludge process and the experiments made at Urbana, Ill. Sludge could be built up by frequently changing the sewage rather than waiting for complete nitrification before making a change. The fertilizer value of the sludge has been shown by experiments with wheat. Discussion by W. F. WILCOX relates to the adaptation of a septic tank by dividing it into 16 chambers, each one the inverted frustum of a pyramid, so that 5 to 7 million gallons per day were satisfactorily treated.

136 **The extent to which sewage can be purified by practical methods of artificial treatment now in use.** H. P. EDDY. *Proc. Eng. Soc. West. Penn.* 32, 226-70. *Surveyor* 50, 238-41. With respect to the activated sludge process, the following features are considered: theory of action; method of operation; aeration; sedimentation; sludge handling; character of effluent; application to trade wastes; and costs. A brief description of the Milwaukee

experiments are given. The method produces a clear, sparkling, well-oxidized effluent and its bacterial efficiency and power to oxidize and remove organic matter, apparently approaches that of the sand filter.

137 **Trial activated sludge unit at Cleveland, O.** R. W. PRATT. *Eng. News* 75, 671-2. Description of a million gallon plant operated on the continuous flow principle, 4 hour aeration period, half-hour settlement. The tank is 60 ft. long, 30 ft. wide and 15 ft. deep, divided into 6 compartments each 9.5 ft. by 30 ft. Four compartments are used for aerating, one for maintaining activity of the sludge and one for sedimentation. Filtros is used as the air diffuser, covering 25% of the tank bottom area.

138 **Give conclusions on activated sludge tests.** T. C. HATTON and W. R. COPELAND. *Eng. Record* 73, 489. *Surveyor* 49, 486. *Chem. Abst.* **10**, 3122. Notes from an elaborate report of the findings at the Milwaukee Sewage Testing Station in the report of the Milwaukee Sewerage Commission for 1915. (Cf. Ref. No. 100.)

139 **Purification of sewage by compressed air.** —. —. BOWES. *Jour. Soc. Chem. Ind.* 35, suppl. 30. British Patent Application 5,215, April 10, 1916.

140 **Plans prepared for Houston, Texas, sewage disposal plant.** NEWS ITEM. *Eng. Record* 73, 561. The north side plant has been designed to accommodate an average daily flow of 12,600,000 gallons and the south side plant 6,300,000 gallons. The estimated cost of disposal plants and pipe lines is $639,000 and the operating cost is given as $61,939 per annum.

141 **Purification of sewage by activated sludge in winter at the sewage testing station, Milwaukee, Wis.** W. R. COPELAND. *Eng. and Contr.* **45**, 386-7. *Jour. Ind. Eng. Chem.* 8, 642-3. *Jour. Bact.* **1**, 457. *Jour. Soc. Chem. Ind.* 35, 904. *Chem. Abst.* **10**, 2260. The winter temperature of Milwaukee sewage averages about 51° F. (10.5° C.) and occasionally falls to 40° F. (4.5 C.) or lower. By increasing the air supply from 1.6 to 2.3 cu. ft. per gallon of sewage, it has been possible to remove about 90% of the bacteria and suspended matter by the continuous flow activated sludge process. The sludge contains about 98% of water, but this can be reduced to 75% by pressing, without the addition of lime, and the sludge press-cake is easily handled and can be converted into fertilizer. On a 10% moisture basis the sludge contains about 5% of nitrogen calculated as ammonia, 1.75% of available phosphoric acid, and 0.4% of potash. It is estimated that one million gallons of Milwaukee sewage, containing from 260 to 440 parts per million of suspended matter, will yield 3,000 to 4,000 gallons of sludge containing 98% water, which is equivalent to about half a ton on a 10% moisture basis. The sludge is being dewatered in a WORTHINGTON press. It is estimated that it will cost $5 to $6 to dry and deliver to the customer a sludge worth $10 to $12. With the outside temperature at times as low as -15° F. (-26.1° C.) and the temperature of the sewage on a few occasions reaching 34° F. (1.1° C.), good bacterial removal and clarification was maintained.

142 **Chemical observations on the activated sludge process as applied to stockyard sewage.** A. LEDERER. *Eng. and Contr.* **45**, 388. *Jour. Ind. Eng. Chem.* 8, 652. *Jour. Bact.* **1**, 457. *Chem. Abst.* **10**, 2260. The stockyards waste lends itself readily to the process, though the free oxygen demand is approximately 8 to 10 times greater than the domestic sewage of Chicago. Temperatures vary between 60° and 90° F. throughout the year at the Center Ave. outlet, and even in the coldest winter weather the fall of temperature in the plant is only a few degrees. The removal of colloidal matter was the only immediate indication of accomplished oxidation. With turbidities of 10 parts per million or less the effluent is stable. The quantity of settling suspended matter in the effluent merely indicated the efficiency of the settling process and has nothing to do with the activated sludge process proper.

143 **Status of activated sludge sewage treatment.** G. T. HAMMOND. *Eng. News* 75, 798-800. *Chem. Abst.* 10, 2115. *Expt. Sta. Record* 35, 490. After visits to five working-scale plants, the author, who has been in engineering charge of the activated sludge experiments at Brooklyn, draws some noteworthy conclusions regarding the probable desirability of preliminary screening, the apparent advantages of pipe-grid as against porous plate diffusers, the uncertainty, but great importance of sludge recovery for fertilizer base and of sludge dewatering. He considers the activated sludge process, while promising, as still in the early experimental stage, but fortunately the experiments are on a large scale and in charge of able men. Illustrations of plants at Brooklyn, Cleveland, Milwaukee, Chicago and Baltimore accompany the article.

144 **Activated sludge Problems.** EDITORIAL. *Eng. News* 75, 809-10. Commenting on the article by GEO. T. HAMMOND (Ref. No. 143), it is noted that the activated sludge process combines clarification, oxidation, and bacterial reduction in a single tank or series of them. The great question is that of costs, though that of air supply seems to be a critical matter. There may be various difficulties besides that of final sludge disposal.

145 **Milwaukee's activated sludge investigations.** R. O. WYNNE-ROBERTS. *Can. Engr.* 30, 473-6, 561-5. *Chem. Abst.* 10, 3123. A resume of results of experiments carried on during the year 1915 by the Milwaukee Sewerage Commission. Analyses are given. (Cf. Ref. No. 100.)

146 **Activated sludge at Houston, Tex.** ANON. *Munic. Jour.* 40, 585-8. Experiments on this method, together with Imhoff tanks, aerated contact beds and electrolytic tanks. Methods and results with activated sludge. Plans adopted for permanent plant.

147 **Sewage disposal by the activated sludge process.** EDITORIAL. *Surveyor* 49, 480. Comment on the Milwaukee results as noted in ref. No. 138 . A valuable feature of the activated sludge process is the possibility of varying the degree of purification by altering the volume of air applied or the aeration period. The degree of purification should first be fixed and the plant built to give this purification.

148 **Activated sludge process on stockyards sewage.** A. LEDERER. *Eng. News* 75. 932. The object of this short paper is to elaborate certain facts of a chemical and biologic nature which have presented themselves in the course of operations, and not to furnish any prescription for the treatment of stockyards waste. The work indicates that the temperature of the liquid treated will be a controlling factor.

149 **Tanks for the purification of sewage.** T. CAINK. Worcester, Eng. British Patent 105,654, May 20, 1916. *Jour. Soc. Chem. Ind.* 36, 611. *Chem Abst.* 11, 2248. The apparatus is designed to be used in the purification of sewage by the activated sludge process and consists of a tank divided into several bays in series and covered with an air-tight roof which prevents the air injected by the diffusers from escaping directly into the atmosphere, but deflects it horizontally to an exit, whereby circulation of the sewage in the tank is set up to effect more efficient aeration. The tank is filled to the roof with sewage. Air is admitted along the bottom of one side of each bay and imparts to the sewage a vertical circulatory motion, which is aided by suitable guiding baffles arranged so as to prevent deposition of the solids on the floor of the bays. In another form, the tank is divided into a number of parallel bays and air is supplied along the side of the first bay only, parallel to the direction of the flow of the sewage. The dividing walls between the bays have openings at the top and bottom to permit of the passage of air to and fro at right angles to the flow of the sewage. This imparts a spiral motion to the sewage in the tank.

150 Activated sludge. EDITORIAL. *Can. Engr.* **30**, 581. Briefly reviews the introduction of the process by DR. FOWLER, (suggested to him by DR. MACLEAN WILSON) and ARDERN & LOCKETT, concluding with this paragraph: "The comprehensive experiments made at Milwaukee have so fully confirmed the statements made by ARDERN & LOCKETT, that there remains but little doubt in the minds of sanitarians generally, that we are to witness a great revolution in the methods of sewage treatment, and in the standards of purification which will in the future be attainable in ordinary everyday practice."

151 Sewage disposal by the activated sludge process. T. C. HATTON. *Can. Engr.* **30**, 590-3. *Chem. Abst.* **10**, 3123. The activated sludge process is compared with sprinkling filters, contact beds, etc., from a biological point of view and from the standpoint of relative areas required. The effect of varying volumes of air, plant design, and sludge handling are discussed, and the results of some of the Milwaukee experiments are given.

152 Manurial value of sewage sludge. G. MUMFORD. *Jour. Bd. Agric.* **23**, 129-35. *Jour. Soc. Chem. Ind.* **35**, 647. A sample of activated sludge obtained at Manchester from domestic sewage lost 69.8% on ignition, and contained 4.3% phosphoric acid and 5.5% nitrogen. Some samples contained as much as 6 or 7% nitrogen, the high nitrogen content being accounted for by assuming that the solid particles of sludge assimilate nitrogen from the liquid portion, the effluent holding very little matter in suspension. The nitrogen of the sludge is in a readily available condition.

153 Activated sludge at Milwaukee. T. C. HATTON. *Munic. Jour.* **40**, 785-7, 824-5, 830. *Chem. Abst.* **10**, 2491. In a paper before the N. Y. State Conference of Mayors and other City Officials, Mr. Hatton stated that the Milwaukee sewage could be treated with 1.75 cu. ft. of free air per gallon of sewage, with 4 hours contact in the presence of 20% activated sludge. Filter-pressing of the sludge is probably feasible, followed by drying. The results obtained at Milwaukee are outlined. MR. G. D. HOLMES in discussion adds that the great problem yet to be solved is the disposal of the watery sludge without offense.

154 Activated sludge sewage disposal. EDITORIAL. *Munic. Jour.* **40**, 833. Comments on MR. T. C. HATTON'S paper. (Ref. No. 153.) Intimates that offensive odors may arise on drying the sludge and that at present the process is too expensive for small cities. Considers plant costs as compared with other processes and suggests caution in adopting the method, notwithstanding the promising nature of it.

155 Artificial means of sewage treatment. ANON. *Eng. & Contg.* **45**, 581-6. *Chem. Abst.* **10**, 2489. From a paper by MR. H. P. EDDY presented at a meeting of the Eng. Soc. of West. Penn., which discusses the general principles of sewage treatment. The activated sludge method is still in the experimental stage, with possibility of high cost of power and the commercial possibilities yet to be demonstrated. The results of the different methods of sewage treatment are compared briefly. (Cf. Ref. No. 136.)

156 Aeration of sewage in the presence of activated sludge. E. J. FORT. *Jour. Ind. Eng. Chem.* **8**, 643. *Chem. Abst.* **10**, 2260. Reviews the experiments at Brooklyn with the 16,000 gallon aerator tank in the fall of 1915, this tank supporting 7½ inches of broken stone on a grid, and operated both on the continuous-flow and the fill-and-draw plan. Tabulated results with and without activated sludge are given. The author believes that the engineer is not yet warranted in recommending the activated sludge process for general adoption.

157 Activated sludge experiments at the sewage disposal plant, Baltimore. C. W. HENDRICK. *Jour. Ind. Eng. Chem.* **8**, 645. *Chem. Abst.* **10**, 2260. Reviews the laboratory and the larger experiments and gives some tabulated

results. Air diffuser troubles are cited with special reference to that caused by the oil which is carried along from the compressor. The possibility of purifying sewage by the activated sludge method is shown, but additional experiments are recommended.

158 **Composition of the effluent air from an activated sludge tank.** F. N. CRAWFORD and E. BARTOW. *Jour. Ind. Eng. Chem.* 8, 646-7. *Chem. Abst.* 10, 2260. The carbon dioxide increases from 4.3 parts per 10,000 in the influent air to 36 to 40 in the effluent air. The oxygen decreases from 20.5% to 19.3%. About 5% of the oxygen in the air is therefore used in the process. (Cf. Ref. No. 335.)

159 **Sewage disposal experiments at Brockton, Mass.** R. S. WESTON. *Jour. Ind. Eng. Chem.* 8, 647-8. *Jour. Soc. Chem. Ind.* 35. 904. *Science, N. S.* 44. 322. *Chem. Abst.* 10, 2261. The activated sludge process promises relief for over-worked filter beds; it does not seem to be practical to use it alone. Fill and draw activated sludge tank, followed by sand bed at 500,000 gallon rate gave excellent results. Continuous process now being tried for clarification alone with good results. Aeration period at least 4 hours. The experiments are being continued.

160 **The activated sludge process in the treatment of tannery wastes.** H. P. EDDY and A. L. FALES. *Jour. Ind. Eng. Chem.* 8, 648. *Jour. Am. Leather Chem. Assoc.* 11, 441-9. *Jour. Soc. Chem. Ind.* 35, 905. *Surveyor* 50, 282-4. *Chem. Abst.* 10, 3123. Wastes are from the manufacture of sheep, calf and kid leather and pulled wools. Average analyses are given of raw wastes and of activated sludge influents and effluents. A 1,000 gallon tank is operated on the fill and draw plan and the method of building up the activated sludge is described. Temperature of waste was kept between 65° and 75° F. by live steam. Aeration for 11 days with 20% sludge, based on 2 hours sedimentation, gave a stable effluent and reduced the ammonia nitrogen 97% and the albuminoid nitrogen 63%. Nitrite and nitrate nitrogen was increased in 17 days from 0 to 35 parts per million. This was mostly nitrite and was not changed to nitrate by 11 days more aeration. Volume of sludge decreased in 28 days from 20 to 7.6%. When tank was filled once a day and air was supplied at the rate of 0.5 cu. ft. per gallon per hour, the effluents were clear and stable. Tables are given showing composition of the sludge and the effects of different periods of sedimentation on the volume of the sludge and the turbidity of the effluents.

161 **Treatment of packing-house sewage by aeration in the presence of activated sludge.** PAUL RUDNICK and G. L. NOBLE. *Jour. Ind. Eng. Chem.* 8, 651-2. *Jour. Am. Leather Chem. Assoc.* 11, 450-3. *Jour. Soc. Chem. Ind.* 35, 904. *Science, N. S.* 44. 323. *Chem. Eng. and Manuf.* 24, 86. *Chem. Abst.* 10, 3123. The sewage treated is a mixture of wastes from all departments of the packing-house and of domestic sewage. It contains about 4 times as much suspended solids as domestic sewage. The tank is operated on the continuous flow plan with a 10 hour aeration using 3 cu. ft. of air per gallon of sewage. The sludge is allowed to settle 40 to 60 minutes, and the effluent is clear and stable for at least 4 days. Typical analyses of effluent give the following nitrogen percents:—Albuminoid 2.4 to 7.4, ammonia 16.2 to 31.2, nitrite 0.07 to 0.60, nitrate 0. Albuminoid, ammonia and total organic nitrogen, total organic matter, and the suspended solids are reduced 66 to 95%. The average analysis of the sludge on a 10% moisture basis is 4.59% nitrogen, 2% phosphoric acid. No sludge drying method satisfactory in all respects has been developed. Purification seems to be independent of depth of aerating chamber.

162 **Development of the purification of sewage by aeration and growths at Lawrence, Mass.** H. W. CLARK. *Jour. Ind. Eng. Chem.* 8, 653-4. *Jour. Soc. Chem. Ind.* 35, 904. *Science, N. S.* 44, 322. *Chem. Abst.* 10, 3116. This

paper describes the discovery and development, at the Lawrence Experiment Station of the Mass. State Dept. of Health, of the method of purifying sewage by aeration and growths, a method quite generally known as the activated sludge method. The paper shows that the method was developed there in 1911 and 1912, that it was shown to DR. GILBERT FOWLER of Manchester, Eng., in the fall of 1912, and that the English work was largely a repetition of the Lawrence work. It quotes from FOWLER and from ARDERN and LOCKETT, his colleagues, to prove that their activated sludge work was based upon the Lawrence work. The paper gives the statement of DR. MACLEAN WILSON of England, made in his presidential address to the Assoc. of Sewage Works Managers, to the effect that the efficiency of growths in the purification of sewage by aeration, was discovered at Lawrence. The paper further describes the Lawrence work during the past 4 years and gives the results of much of this work, with the conclusions that the governing factors of the success of this process of sewage treatment are, (1) the cost of power for supplying the large volumes of air necessary; (2) a sewage that readily yields itself to this method of treatment.

163 London sewage experiments. NEWS ITEM. *Eng. News* **76,** 37. Activated sludge experiments on London sewage are being conducted by the County Council of London, Eng., according to the last annual report of the Council.

164 Sewage treatment recommended for Lima, Ohio. NEWS ITEM. *Eng. News* **76,** 46. Riensch-Wurl screens and activated sludge tanks have been recommended to treat the sewage of Lima, O., by MR. G. W. FULLER. The plan is to operate the screens the year round, but at the outset to run the activated sludge tanks about 7 months in the year when the flow of the Ottawa river is relatively small.

165 Purification of sewage and other liquids. W. JONES and JONES & ATTWOOD, L'TD., Stourbridge, Eng. British Patent 104,187, July 11, 1916. *Jour. Soc. Chem. Ind.* **36,** 471. *Chem. Abst.* **11,** 1868. In treating sewage and other impure liquids by aeration in the presence of bacterial sludge, the sewage enters at the end of a long tank divided lengthwise down the middle and having a bottom of ridge and furrow form, with air diffusers in the bottom of the furrows. The flow is directed by baffles and submerged walls to the opposite end, where the sewage turns at right angles into the other division of the tank, along which it flows in the reverse direction. Before being discharged from the tank, the sludge is deposited in settling chambers having bottoms sloping towards the dividing wall of the tank. At these points part of the wall is cut away to allow connection with the other division of the tank. At the foot of the wall on the first division side is an air diffuser, and a low wall is built around the diffuser and both sides of the opening in the wall so as to form a well. When the air supply is turned on, an upward current of sludge and sewage is produced on that side of the wall, and a current of sludge and sewage is induced to flow through the opening from the other side. In this way the sludge can be transferred from the exit to the entry end of the tank. At intervals along the base of the dividing wall there are openings similar to the foregoing; in this way sludge can be transferred from one side to the other along the whole length of the tank. In another form of apparatus, instead of one long tank, there are a number of short tanks arranged side by side and connected in series; in this form the tanks have a flat bottom and the air diffusers are placed at each end of the short tanks.

166 The sewage problem. SIDNEY BARWISE. *Surveyor* **50,** 29-30. A history of sewage filtration, contact beds, etc. The activated sludge treatment is preferable if the sewage must be pumped. Mechanical processes of introducing air are hopeful. Research should be encouraged.

167 Activated sludge experiments at Sheffield. (Eng.) DISCUSSION. *Surveyor* **50,** 33-4. In the discussion of J. HAWORTH'S paper (Ref. No. 168)

C. H. BALL claimed that acid wastes were very detrimental to the process. J. H. KERSHAW said that sulphocyanides in gas liquors could be eliminated by aeration. J. HAWORTH said that a fungus growth had been noted inside the porous tiles used at Sheffield. Filtros plates were found to give the best air distribution.

168 **Experimental work with regard to the purification of sewage by activated sludge.** JOHN HAWORTH. *Surveyor* 50, 40-2. *Can. Engr.* 31, 167-9. *Contract Record* 30, 959-62. *Water and Water Eng.* 18, 265-7. *Chem. Abst.* 10, 3123, 11, 177. Experiments at Sheffield, Eng., extending over a period of 4 years are reported in a paper before the Assoc. of Managers of Sewage Disposal Works. Effluents from contact beds were subjected to (1) aeration by jets of air, (2) aeration through land tiles and silica brick, (3) aeration by allowing the liquid to fall in sprays, (4) aeration on percolating filters of various depths, (5) sand filtration and (6) precipitation by chemicals. Activated sludge experiments were carried out on tank effluents, on mixtures of tank effluents and settled sewage, on settled sewage and on crude sewage. With porous diffusers well clarified effluents were usually obtained which were within the limits of allowed impurity. Acid trade wastes unless neutralized, temporarily destroyed the activity of the sludge. Unequal porosity caused uneven aeration. Porous tiles became choked after a few months due to dust and grease in the compressed air and by bacterial growths in the pores of the plates. Cracking of the tiles caused shut-downs for repairs. An apparatus designed in 1880 for the oxidation of oils gave satisfactory results in aerating sewage. It consisted of a vertical cylindrical tube fitted with a spindle carrying an Archimedean screw or propellor blades which sucked sewage and air to the bottom of the cylinder upon being revolved. Clarified non-putrescible effluents were obtained from settled sewage after 5 hours aeration in a tank equipped with a series of perforated steam pipes covered with 2 feet of clinker broken into ¾ inch cubes. Crude sewage was satisfactorily treated for 6 months in a small iron tank equipped with a horizontal shaft to which were attached hollow paddles that trapped small volumes of air when rotated above the surface of the contained sewage. It was concluded that (1) a normal sewage may be clarified by the activated sludge method, (2) that mechanical circulation with minimum aeration is efficient, (3) that trade wastes may interfere seriously with the process, (4) that further investigation is needed with respect to modes of application of the sludge to the sewage, periodical removal of the surplus sludge and the effect of such removal on the process, and the costs of plant and upkeep before older plants and methods can be abandoned, (5) that skilled control of the process will be essential, (6) that, while the resulting sludge is undoubtedly richer in nitrogenous organic matter than ordinary sewage sludge, it remains to be proved by actual agricultural trials that such nitrogen is in a form suitable for ready assimilation by plant life, and that the sludge will be a valuable fertilizer.

169 **Appoint committee on the activated sludge process.** NEWS ITEM. *Eng. Record* 74, 91. At an informal meeting of members of the Am. Soc. of Civil Eng. held at Pittsburgh on June 28, 1916, F. A. DALLYN, Toronto; G. T. HAMMOND, Brooklyn, and T. C. HATTON, Milwaukee, were appointed a committee to prepare standard definitions and other terms relating to the activated sludge process of sewage treatment. They will also tabulate and distribute a summary of the work now being done or contemplated, and suggest such correlation of current work as may be desirable. The question of submitting to the Commissioner of Patents information relating to priority of knowledge of the activated sludge process, was left with PROF. EARLE B. PHELPS, H. W. CLARK and DR. EDWARD BARTOW.

170 **Air diffuser experiences with activated sludge tanks.** ANON. *Eng. News* 76, 106-10. *Surveyor* 50, 160-3. *Chem. Abst.* 10, 2779. Differences of experiences and opinions as to the use of porous block and perforated pipe diffusers for intimately mixing air and agitating sewage in activated sludge

tanks are expressed by engineers in charge of tests and working plants at Milwaukee (MR. HATTON), Baltimore (MR. HENDRICK, MR. FRANK), Brooklyn (MR. HAMMOND), Cleveland (MR. PRATT), Urbana, Ill., (DR. BARTOW), Chicago (MR. PEARSE, MR. NOBLE), and Houston, Texas, (MR. SANDS). The majority find filtros satisfactory. Two prefer perforated grids.

171 **Sewage plans for Matawan, N. J.** NEWS ITEM. *Eng. News* 76, 140. Plans for an activated sludge plant to treat the sewage of Matawan, N. J., drawn by G. A. JOHNSON, N. Y. City, have been approved by the State Board of Health.

172 **The activated sludge process. Results at Worcester, Eng.** EDITORIAL. *Surveyor* 50, 83. JONES & ATTWOOD are conducting tests at Worcester, treating half the flow. The tests are to continue for one year under agreement that 750,000 g. p. d. are to be treated with an effluent containing not more than 40 p. p. m. of suspended solids and which shall not be capable of putrefaction. Thus far five samples show better than these limits.

173 **Tests show activated sludge process adapted to treatment of stock-yards wastes.** M. D. HARDING, G. L. NOBLE and P. RUDNICK. *Eng. Record* 74, 137-8. *Chem. Abst.* 10, 3123. The sewage of ARMOUR & Co., Chicago, averages 700 p. p. m. suspended matter and is of a complex nature. Using 15% by volume of activated sludge with beef-slaughtering sewage, a stable effluent was obtained after two days aeration; long before clarification. Experiments are being conducted in a 30,000 gallon tank on the continuous flow plan, the air being distributed by means of one inch galvanized-iron pipes, perforated with one-twenty-fifth inch holes spaced two inches apart. Processes for dewatering the sludge are being studied. The estimated cost of treatment per million gallons of sewage is $3, exclusive of interest, depreciation and repairs.

174 **Progress in the treatment of sewage.** EDITORIAL. *Surveyor* 50, 93. Comment on the article of S. BARWISE, (Ref. No. 166) and reference to J. HAWORTH'S method of mechanical agitation at Worcester. Expresses the belief that further investigations should be directed along this line.

175 **Stockyard wastes can be treated by activated sludge process.** ANON. *Contract Record* 30, 788-90. Digest of the article by HARDING, NOBLE and RUDNICK appearing in the Eng. Record. (Cf. Ref. No. 173.)

176 **Baltimore activated sludge air diffusers.** L. C. FRANK. *Eng. News* 76, 267. *Chem. Abst.* 10, 3123. It was found that some of the old filtros disks showed evidence of disintegration upon removal from the umbrella-shaped diffuser grid.

177 **Apparatus for introducing gases into intimate contact with liquid sewage.** G. W. MOTTRAM, Deepcar, near Sheffield, Eng. U. S. Patent 1,195,067, Aug. 15, 1916. (Application filed Feb. 17, 1916. 3 claims.) *Off. Gaz.* 229, 872. *Chem. Abst.* 10, 2493. Claim 3:—The combination, with a tank of sewage, of a vertical air supply pipe provided with laterally projecting branch pipes arranged in the lower part of the tank and provided with outlet holes, tubular casings of porous material through which air can pass inclosing the said branch pipes, and means for revolving same. (Cf. British pat. 2,421. Ref. No. 34.)

178 **Activated sludge progress.** EDITORIAL. *Eng. News* 76, 366. Refers to several plants in the United States and England, cites the need of caution in adopting the method because of the many details yet to be worked out, and suggests that engineers should give it careful consideration because it would fall little short of revolutionizing sewage disposal should its highest promises be realized.

179 **Activated sludge plant for Hermosa Beach, Calif.** NEWS ITEM. *Eng. News* 76, 380. *Munic. Engr.* 51, 105. The first Pacific coast city to project an activated sludge plant has authorized the construction of a "BROSIUS system of activated and aerated sludge treatment." The plant will consist of 8 concrete tanks each 12.5 ft. in diameter by 13 ft. deep.

180 **Activated sludge treatment in America.** ANON. *Engineer* 122, 170. Refers to the Milwaukee plant and the recent papers by T. C. HATTON; the Baltimore and Brooklyn experimental plants, and to G. T. HAMMOND'S recent investigation of the subject. This article deals especially with the various air diffusing means employed, filtros being fully described.

181 **Apparatus for aerating sewage.** GRIFFITHS and HARTLEY. British Patent Application No. 12,084, Aug. 26, 1916. *Jour. Soc. Chem. Ind.* 35, Suppl. 55.

182 **How other cities in the United States are disposing of their sewage.** R. V. ORBISON and T. D. ALLIN. *Pamphlet* (Sept. 1916) *Proc. 19th Ann. Conv. Pacific Munic.* 61-77. The activated sludge process referred to as in Ref. No's. 210, 223 and 250.

183 **The activated sludge process. An American Committee.** ANON. *Surveyor* 50, 247. On Sept. 15, 1916, members of the Am. Soc. C. E. met at Pittsburgh and appointed F. A. DALLYN, G. T. HAMMOND and T. C. HATTON a committee to prepare standard definitions of the activated sludge process and to tabulate and distribute a summary of the work in progress. A patent committee was also appointed consisting of E. B. PHELPS, H. W. CLARK and DR. E. BARTOW to present evidence of priority of knowledge of the activated sludge process to the Commissioner of Patents.

184 **Activated sludge in India.** NEWS ITEM. *Eng. News* 76, 624. Activated sludge studies at three points in India, with particular attention to fertilizer possibiltes, are to be made by DR. G. J. FOWLER, formerly of Manchester, Eng.

185 **Present status of activated sludge.** EDITORIAL. *Munic. Jour.* 41, 383-4. *Chem. Abst.* 10, 3122. The editor indicates that the process is still in the experimental stage and that the cost of handling the sludge is very uncertain.

186 **Bacteriological study of sewage purification by aeration.** R. RUSSEL and DR. E. BARTOW. *Univ. Ill. Bull.* 14, 348-58. (Water Survey Series No. 13) *Chem. Abst.* 11, 1707. *Expt. Sta. Record* 38, 490. The investigation has shown the following bacteriological features of the activated sludge process of sewage purification: (1) There is a large and consistent reduction of the total number of bacteria in the sewage; (2) the actual stabilization process is due to a typical aerobic bacterial flora which gains almost complete ascendency, the other inhabitants being largely incidental; (3) the actual nitrification is accomplished by two typical known nitrifiers "Nitrosomonas" and "Nitrobacter."

187 **Nitrogen in activated sludge.** EDITORIAL. *Eng. News* 76, 663. Refers to a paper by MR. COPELAND (Ref. No. 188) and the difficulties of dewatering activated sludge. "If a process of sewage disposal could be perfected that would yield a sludge convertible into fertilizing material at less than capital charges and operating expenses, and without causing a nuisance, one of the most baffling municipal problems of the last half century would be solved."

188 **Nitrogen from sewage sludge, plain and activated.** W. R. COPELAND. *Eng. News* 76, 665-6. *Can. Engr.* 31, 340. *Munic. Jour.* 41, 446. *Chem. Abst.* 10, 3124; 11, 509. The practicability of recovering nitrogen from sewage

depends upon (1) the amount present, (2) the cost of recovering and disposing of it, and (3) its market value. Nitrogen is largely recovered from suspended matter. Sludge from best known processes ranges from 1.2 to 3% nitrogen, whereas activated sludge at Milwaukee contains 5 to 9% wet, and 4 to 4.5% when dry. Estimated cost of recovery is $10 to $12 per ton with 10% moisture, with market value from $9 to $15.

189 **Discussion of Mr. Copeland's paper on nitrogen recovery.** G. W. FULLER. *Eng. News* 76, 667. *Eng. Record* 74, 445. *Chem. Abst.* 11, 80. Mr. Fuller points out that while the activated sludge process saves loss of nitrogen, the real problem is to economically dewater the sludge. Possible use of the DICKSON yeast fermentation process is suggested, with the final reduction of water content by means of heat dryers.

190 **Commercial possibilities with activated sludge.** EDITORIAL. *Eng. Record* 74, 428. Commenting on MR. COPELAND'S paper (Ref. No. 191) it is the opinion that if sewage treatment plants can produce valuable fertilizer material, their usefulness will increase, and the reduced operating costs will also stimulate plant construction, especially where present sewage disposal methods create a nuisance.

191 **Nitrogen recovery from sewage sludge reaches a commercially practicable stage.** W. R. COPELAND. *Eng. Record* 74, 444-5. *Chem. Abst.* 11, 273. Parallel experiments on Milwaukee sewage showed that most of the nitrogen in the sewage passed out in the suspended and colloidal matters in the effluent when treated by the Imhoff tank, but in the activated sludge method it was stored up in the sludge. As secured in the settling tank activated sludge contained 98-9% of water which has been difficult to remove. Latest information favors a combination of settling and decantation to reduce to 96%, filter-pressing to bring down to 75%, and dewatering of the press-cake in a drier to 10% or less. Lime in filter-pressing was shown to be unnecessary. Little or no nitrogen was lost in drying. Data indicates that Milwaukee sewage will contain 4.6 to 5% nitrogen as ammonia, 0.6 to 0.7% available phosphoric acid, 0.25 to 0.50% potash and 3 to 4% fat. Tables give analyses of sewage and of effluents and sludges obtained by both Imhoff and activated sludge processes.

192 **Aeration suggested for sludge disposal.** G. T. HAMMOND. *Eng. Record* 74, 448-9. *Surveyor* 50, 400-1. *Chem. Abst.* 11, 375. Two to four thousand gallons of sludge containing 96 to 99% of water result from each million gallons of sewage treated by the activated sludge process. Many cities would not install expensive dewatering plants, and for these fine screening, partial drying by pressing or prolonged aeration of the sludge offer possibilities for minimizaton of the amount of sludge produced. Long contnued aeration reduces activated sludge to 10% or less of its original volume. Experimentation would be necessary to produce properly designed plants for removing excess water as the cost of aerating large volumes would be prohibitive.

193 **Large activated sludge plant at Milwaukee, Wis.** ANON. *Eng. News* 76 686-8. *Chem. Abst.* 11, 510. A two million gallon daily capacity plant costing $61,536 is described. Operating data is given. Steeper slopes of 60 degrees from the horizontal are recommended for hopper of settling tank. Air pressure required is increasing with use, and larger amounts in cold weather. Immediate settling following aeration is necessary, with constant removal of the sludge.

194 **Apparatus for aerating sewage and other foul liquids.** R. AMES, Brighton, Eng. British Patent 110,197, Oct. 13, 1916. (Addition to British Patent 104,361. Ref. No. 127). *Jour. Soc. Chem. Ind.* 36, 1247. The original apparatus is improved by providing above the tank a rotary chamber, to

which the incoming sewage is supplied. From this chamber the sewage flows into troughs, fixed to the chamber on either side, from which depend open-topped vertical pipes with bell-mouth bottoms reaching to within a few inches of the bottom of the tank. The compressed air supply comes from an air chamber on the top of the sewage chamber, the air being conveyed by pipes which pass down the inside of the vertical sewage pipes and end in atomizers located in the bell-mouths of the sewage pipes.

195 **Sewage treatment by aeration and activation.** G. T. HAMMOND. *Can. Engr.* 31, 305-11. *Surveyor* 50, 453-5; 479-80. *Proc. Am. Soc. Munic. Impvts.* 23, 327-403. *Chem. Abst.* 11, 1867. (Also in pamphlet form, reprinted from the Proc. Am. Soc. Munic. Impvts., 1916, with discussion of all activated sludge papers presented at that meeting. pp. 101). A very complete and critical review of the activated sludge process. Refers to sewage aeration experiments from 1884 to the present time, and as a result of personal visits to the several plants, or by correspondence with those in charge, the author has collected in this article all the important data of the plants at Baltimore, Brooklyn, Champaign, Ill., Chicago, (Armour and Sanit. Dist. plants) Cleveland, Edmonton, Can., Fort Worth, Tex., (Armour plant), Houston, Tex., Lawrence, Mass., Milwaukee, Regina, Can., San Marcos, Tex., and Urbana, Ill. No forecast of the value of the activated sludge process can be made at this time, but it is noted that methods of air distribution and sludge treatment still require study. The apparent advantages are a clear and stable effluent from a plant requiring small area, and freedom from odor.

196 **Activated sludge sewage treatment.** ANON. *Munic. Jour.* 41, 480-3; 510-13. A review of the experiments being conducted and results obtained at 11 plants, with an outline of the provisions for co-operation of experimenters. Abstracts of several papers presented at the 1916 meeting Am. Soc. Munic. Impvts.

197 **Present status of activated sludge.** ANON. *Water and Water Eng.* 18, 257-8. *Chem. Abst.* 11, 178. While the activated sludge process has been more thoroughly and promptly investigated than any other method of sewage disposal, yet the plant at San Marcos, Texas, treating about 150,000 gallons of sewage per day, is the only plant in actual operation and not under experimental conditions. The work at Milwaukee is reviewed. Engineers are cautioned against hasty copying of experimental plants.

198 **The activated sludge process.** EDITORIAL. *Surveyor* 50, 373-4. Comment on the interesting results at Manchester, Eng. Experiments on sedimentation are needed. The process can be adjusted to the character of the sewage and the quality of effluent desired. Desirable to purify to a greater degree when stream flow is at a minimum, and to vary air supply accordingly.

199 **The activated sludge process. Manchester research work.** ANON. *Surveyor* 50, 379-80. *Chem. Abst.* 11, 2517. A digest of the annual report of the Manchester Rivers Committee. With a weak domestic sewage tried at the Withington works, satisfactory purification was not dependent on the stage to which nitrification was carried, nor was the question of temperature as serious as with sewage containing trade wastes, satisfactory purification being maintained with air temperatures below zero, and sewage temperatures from 5 to 10.

200 **Some remarks on activated sludge.** W. T. CARPENTER and M. P. HOROWITZ. *Am. Jour. Public Health* 6, 1218-23. *Chem. Abst.* 11, 1224. An aerated contact bed was fitted up in a 50 gallon barrel. After 5 hours aeration the liquid drawn from the barrel was practically devoid of suspended matter and purified. Purification was complete after 20 hours. A table of results is given from which it is seen that the rate of fall of demand for

oxygen diminishes throughout the cycle, thus showing that the action proceeds rapidly at first and that a definite amount of air would be most advantageously used by blowing it rapidly in the beginning and more slowly later. It is claimed that while a short period of retention will suffice to settle the sludge which has been aerated 20 hours without any addition of fresh sewage, a longer period is necessary when operation is continuous during a shorter aeration period. Short-circuiting the sewage can be minimized by dividing the retention among several smaller tanks in series or by using one tank with a length great in proportion to its breadth and height.

201 **Mechanical agitation of sewage proved unsuccessful.** C. H. NORDELL, *Eng. News* 76, 856. *Chem. Abst.* 11, 509. Description of some experiments made with screw propellers and stirrers of various forms, from which evidence is deduced that agitation itself plays a minor part, liberal aeration being essential for the efficient and economical working of the activated sludge process.

202 **Definitions of sewerage and sewage disposal terms.** ANON. *Eng. News* 76, 858. *Am. Jour. Public Health* 7, 847. The committee on the sewerage and sewage disposal of the sanitary section of the Am. Public Health Assoc., with the co-operation of eminent engineers, suggests the following definition for the activated sludge process:—"Activated-Sludge Process consists in the agitation of a mixture of sewage with about 15% or more of its volume of bacterially active liquid sludge in the presence of ample atmospheric oxygen, for a sufficient period of time to at least coagulate a large proportion of the collodial substances, followed by sedimentation adequate for the subsidence of the sludge flocculi; the activated sludge having been previously produced by aeration of successive portions of sewage and maintained in its active condition by adequate aeration by itself or in contact with sewage."

203 **Digestion of activated sludge.** H. P. EDDY. *Proc. Am. Soc. Munic. Impvts.* 23, 429-39. *Can. Engr.* 31, 353-5. *Surveyor* 50, 504-6. Details are given of the operation of an experimental activated sludge plant on tannery wastes, including analytical data, sludge accumulation period, sludge activation period, period of operation on one filling per day, with increased proportion of sludge, on two fillings per day, with and without sludge removal, quantity of sludge produced, sludge digestion, digestion of fats, increasing the volume of sludge by its partial removal. About 10 cu. ft. of air per gallon of sewage were used with 12 hours aeration on the fill and draw plan. Sludge volume will not exceed 10,000 gallons per million gallons of sewage. 88.7% of the fats were digested and the mineral matter in the sludge decreased 77.8%.

204 **Comparative costs of construction and operation of the activated sludge and Imhoff trickling-filter process of sewage treatment.** ANON. *Eng. Record* 74, 557. *Eng. & Contg.* 47, 154-7. From a paper by H. P. EDDY presented to the West. Soc. of Engs., covering an engineering study of the two processes based on comparative designs for Fitchburg, Mass., in which the total estimated cost of the Imhoff plant is $431,170 and of the activated sludge plant $313,880, engineering and administration charges included. Both plants designed for 5.5 million gallons daily capacity. Estimated annual costs are $17,080 for the Imhoff and $40,140 for the activated sludge. Advantages and disadvantages of both methods are discussed. (Cf. Ref. No. 217).

205 **The pioneer activated sludge plant.** ANON. *Contract Record* 30, 1066-8. A description of the new 1,600,000 g. p. d. installation at Milwaukee, (Ref. No. 70) covering the general scheme, air diffuser experiments, and some results of operation.

206 **Disposal of sludge from activated process.** ANON. *Contract Record* 30, 1074. Review of a paper by G. T. HAMMOND in which the work of

FOWLER and others, and the experiments at Brooklyn, Lawrence, Milwaukee and ARMOUR & Co., Chicago, are referred to. The SCHAEFER-TER-MEER centrifugal sludge drier, the WORTHINGTON press and the DICKSON yeast process are considered in connection with sludge dewatering. The long continued aeration of the sludge is also suggested as a means of minimizing the surplus sludge.

207 **Results and conclusions from a year's operation of the activated sludge sewage treatment plant at Milwaukee.** ANON. *Eng. & Contg.* 46, 407-9. *Chem. Abst.* 11, 510. *Expt. Sta. Record* 36, 489. Digest of a paper by T. C. HATTON before the Am. Soc. Munic. Impvts., 1916 meeting, covering work more fully described in the annual report of the testing station. (Cf. Ref. No. 227).

208 **Activated sludge novelties at Hermosa Beach, Calif.** A. M. BROSIUS. *Eng. News* 76, 890-2. *Chem. Abst.* 11, 510. This plant handles 400,000 gallons of sewage per day with an aeration period of 3 hours. 60 kw. hours are required per 100,000 gallons treated. A submerged propeller or diffuser wheel in the bottom of a circular tank draws air and sewage down through a central foam chamber to the bottom of the tank, from which both pass upwards. Air under one pound pressure will also be admitted to each central pipe.

209 **Terms used in sewerage and sewage disposal. An American Committee's definitions.** ANON. *Surveyor* 50, 430-2. From a report of the committee of the Am. Pub. Health Assoc., referring to activated sludge as in Ref. No. 202.

210 **Activated sludge given preference.** T. D. ALLIN and R. V. ORBISON. *Eng. Record* 74, 628. *Chem. Abst.* 11, 375. After visiting several sewage treatment plants throughout this country in behalf of the city of Pasadena, Calif., the committee reports that the activated sludge process occupies less space, costs less for construction, gives a better effluent and is absolutely odorless, as compared to Imhoff tank and the sprinkling filter process. The cost of operation is higher but the greater fertilizing value of activated sludge will reduce the difference. (Cf. Ref. Nos. 182, 223, and 250).

211 **Activated sludge experiments at the University of Illinois.** E. BARTOW, F. W. MOHLMAN and J. F. SCHNELLBACH. *Eng. News* 76, 972-3. *Surveyor* 51, 6. *Am. Jour. Public Health* 7, 679. *Chem. Abst.* 11, 509. The plant handles about 150,000 gallons daily of domestic sewage, using 2 cu. ft. of air per gallon. Stable effluents have usually been obtained. The settling chamber—24 to 37 minute period—has proved too small.

212 **Recommends isolated sewage treatment plants for lake cities north of Chicago.** J. W. ALVORD, H. P. EDDY and G. W. FULLER. *Eng. Record* 74, 656-8. *Chem. Abst.* 11, 679. The activated sludge process is too expensive for local conditions.

213 **Bottom of pipe perforated for air distribution.** ANON. *Eng. Record* 74, 660. Air distribution in the activated sludge plant at Edmonton, Can., is accomplished by pipes perforated on the under side with ⅛-inch holes, 3-inch centers. Provision is made for lifting each air line independently.

214 **Chicago sewage treatment and dilution.** NEWS ITEM. *Eng. News* 76, 1056. *Eng. Record* 74, 695. *Munic. Jour.* 41, 677. *Chem. Abst.* 11, 510. Among the important improvements in the sewage disposal system of Chicago, there is a recommendation by the Board of Trustees of the Sanitary District for the treatment of domestic sewage centering at the 39th street pumping station—from an area of about 22 square miles—by settling basins or an activated sludge plant in the vicinity of this station.

215 **Mechanical agitation and aeration and trade wastes in the activated sludge process.** ANON. *Munic. Eng'rg.* 51, 234-5. From a paper by JOHN HAWORTH presented at a meeting of the Assoc. of Mgrs. of Sewage Disposal Works held at Sheffield, Eng., dealing with the activated sludge work in that city. (Cf. Ref. No. 168).

216 **A new type of trickling filter.** G. G. NASMITH. *Jour. Royal Sanit. Inst.* 37, (Dec. 1916). *Surveyor* 51, 4-5. *Expt. Sta. Record* 37, 488. The author states that the principles of the trickling filter and the activated sludge process are identical. In the first, the sewage trickles over the bacterial mass in the air; in the activated sludge process air is passed into the sewage in contact with the bacterial mass; the end results being exactly the same.

217 **A comparison of the activated sludge and the Imhoff tank-trickling filter processes of sewage treatment.** H. P. EDDY. *Jour. West. Soc. Engs.* 21, 816-52. *Engineering* 104, 288-90, 319-20. *Surveyor* 51, 370-2. *Expt. Sta. Record* 37, 694. A detailed specific comparison of the two methods from which the author concludes that, "At the present time it appears that the Imhoff tank-trickling filter process is a less expensive means of oxidizing the organic matter of sewage and industrial wastes than the activated sludge process, where oxidation alone is considered. If the areas of land required for isolation, the loss of head in the plant, the danger of objectionable odors and of fly annoyance, and other disadvantages of the trickling filter process are of marked importance in any specific case, the balance may be decidedly in favor of the activated sludge process, even in its present state of development." Comparative cost estimates are included. (Cf. Ref. No. 204).

218 **Recovery of fats and nitrogen compounds from sewage.** S. RIDEAL. *Chem. Trade Jour.* 59, 571-2. *Jour. Soc. Chem. Ind.* 36, 44. *Can. Engr.* 32, 82, 157. *Chem. Abst.* 11, 859, 1225. *Expt. Sta. Record* 38, 625. Dried active sludge with 10% moisture, contains 5 to 9% N and if retorted should give higher yields of ammoniacal liquor than are obtained from coal in gas works. To recover nitrates from effluents it is suggested that a filter bed with no effluent drain, protected from rainfall, might be irrigated with the effluent so that nitrates would become gradually concentrated by evaporation. "If all the nitrogen in sewage could be recovered, it is estimated that the military camps would yield 11,640 tons and the civil population 116,400 tons per annum."

219 **Activated sludge results at Cleveland.** R. W. PRATT and G. B. GASCOIGNE. *Eng. News* 76, 1061-6, 1124-8. *Chem. Abst.* 11, 509. The conditions require only a low degree of purification for the sewage from 75% of the population. To remove iron from the sewage requires ¾ hour more aeration than clarification. The sewage treated contains in parts per million:— Suspended matter 250, organic nitrogen 8.5, free ammonia 12.1, iron 21, occasionally up to 350. Filtros plates were used for air distribution, in ratio of plate surface to tank area, 1 to 5. Some clogging has been noted. The tanks are 15 feet 1 inch deep, requiring 0.75 cu. ft. free air per gallon of sewage for clarification. With equal aeration for liquid and solid, a 3 hour period is required. In the horizontal flow settling basin a 30 minute period is ample with a velocity of 1 foot per minute. Steep bottom slopes are required. 25% of the sewage treated is pumped back. Very careful operation is required. Minimum cost for labor and power per million gallons is $4.50 with power at 0.75 cent per kw. hour. Analytical results are given. Re-aeration of the sludge with 20 to 25 cu. ft. of air per gallon improves its drying and keeping qualities. Separate sludge digestion is possible. Unless the unit quantities of sludge produced are materally lessened, the use of sand beds for dewatering is financially prohibitive. Centrifugals have reduced sludge moisture to 85%. Available data indicate that presses are suitable for primary dewatering, irrespective of whether or not the sludge war-

rants further drying for fertilizers. Present data are insufficient to estimate the cost of sludge disposal. The nitrogen value in Cleveland sludge may be about $5.50 per million gallons of sewage.

220 **The attractiveness of the activated sludge process to sanitary engineers.** EDITORIAL. *Can. Engr.* **31**, 475. "Probably there has never been an innovation which ever took so firm a hold of sanitary engineers and has engaged the attention of so many students of sewage disposal as the activated sludge process. A surprisingly large number of municipalities and industrial plants throughout the continent are either conducting experimental plants or are laying plans to do so. Out of all this the science of sanitary engineering should emerge the richer."

221 **Tanks for the purification of sewage.** G. W. and J. F. NAYLOR, Denby Dale, Yorks, Eng. British Patent 111,548, Dec. 7, 1916. *Jour. Soc. Chem. Ind.* **37**, 72A. The air diffusing means along the bottom of the tank for the treatment of sewage by diffusion of air in small bubbles, may consist of non-porous tubes with small perforations on their under side, covered by strips of cloth tightly encircling the tubes. The whole length of the tube is enclosed by a cloth casing kept from touching the under side of the tube by depending stays. The air from the perforations in the tube diffuses through the cloth casing, mainly at the sides. The tubes may also be made of porous earthenware, the upper surfaces being painted over so that air escapes from the sides only.

222 **Purification of sewage and other impure liquids.** W. JONES, Stourbridge, and JONES & ATTWOOD, LT'D., Amblecote, Eng. British Patent 111,720, Dec. 9, 1916. *Jour. Soc. Chem. Ind.* **37**, 72A. *Chem. Abst.* **12**, 597. Crude sewage enters a treatment tank through a hydropneumatic appliance whereby a mixture of sewage and air is delivered well below the surface into the body of the liquid in the tank. The bottom of the tank is of inverted conical shape with a sump at the apex, and the dilute sludge passes out by the sump into a separate tank with ridged bottom provided with air diffusers, whereby it is aerated and circulated. This invigorated sludge is then returned by an air lift to the top of the liquid in the sewage tank. In another form of the tank, the mixture of sewage and air is delivered into radial arms at the level of the conical portion of the tank, and as it issues from these through a series of holes along one side, it causes them to revolve and bring about a perfect distribution. The process may be carried out also in several tanks connected in series.

223 **Sewage disposal methods of 16 cities.** ANON. *Eng. & Contg.* **46**, 534-6. *Pacific Municipalities*, March, 1917. From a report by T. D. ALLIN and R. V. ORBISON referring to the activated sludge plants at Baltimore, Chicago, Cleveland, Milwaukee, and the contemplated plant at Worcester, Mass. (Cf. Ref. Nos. 182, 210 and 250).

224 **Activated sludge process.** ANON. *Can. Engr.* **31**, 489-90. *Ann. Report Manchester Rivers Com.* (1916) Experiment has demonstrated that the air supply should be filtered and the sewage screened from detritus. Abnormal amounts of trade wastes interfere with the process. The process can be operated in cold weather. Clarification is independent of nitrification.

225 **Aerating apparatus.** C. H. NORDELL, Milwaukee, Wis. U. S. Patent 1,208,821, Dec. 19, 1916. (Application filed March 23, 1916. 1 claim.) *Off. Gaz.* **233**, 800. *Jour. Soc. Chem. Ind.* **36**, 201. A container for sludge having a bottom composed of wooden slabs cut transversely of the grain to form minute elastic air passages for air, a casing below the wood slab bottom forming an air chamber, and a means for introducing air under pressure into the chamber whereby it is forced through the fibrous passages of the wood

slabs to form minute bubbles for uniformly aerating the body of sludge that is supported by the fibrous bottom. (Cf. U. S. Patent 1,281,816. Ref. No. 427).

226 **Community activated sludge plant for Chicago stockyards.** NEWS ITEM. *Eng. Record* 74, 784. Engineers of the stockyards interests and the Sanitary District of Chicago, after making a joint study of the proper disposal system, agree that the activated sludge method will handle the sewage and conclude that a community plant to take care of all the wastes from all the packing industries is better than the disposal by each company of its own wastes.

227 **Third Annual Report of the Milwaukee Sewerage Commission.** T. C. HATTON and W. R. COPELAND. *Pamphlet* pp. 127. (Dec. 31, 1916) An elaborate report on the activated sludge work for the year ending Dec. 31, 1916, at the sewage testing station. Of all the processes experimented with, the activated sludge process appears to be the only one which fits the existing conditions in Milwaukee. The maximum volume of air required to produce a stable effluent from which 95% bacteria and 98% suspended solids have been removed, is 2 cu. ft. per gallon of sewage, based on 10 ft. depth of sewage in the aerating tank. Maximum aeration period, 4 hours, and the percentage of sludge carried may vary from 15 to 25 without materially effecting the results. Sedimentation period required is from 40 to 50 minutes, with a maximum horizontal velocity of 3 ft., and a vertical velocity of about 8 inches per minute. Slopes for successfully removing settled sludge should be from 1 to 2, to 1 to 3. Breaking up the air into small bubbles increases the O absorbed, but sufficient air must be used to manitain the solids in suspension. Filtros plates are satisfactory air diffusers, but all oil and dust should be excluded from the air lines. Wood plates give smaller bubbles than filtros at less loss of pressure, but insufficient experience does not warrant their adoption. Sewage can be clarified in from 1 to 1.5 hours aeration in the presence of well activated sludge, by using 0.5 to 1 cu. ft. of air per gallon of sewage in a 10 ft. deep tank, but the activity of the sludge cannot be maintained without additional aeration. Storm flow can be taken care of by increasing the volume of air and sludge, but extra settlement capacity must be provided if a standard effluent is to be maintained. Conduits should not be used as the sludge settles too quickly. Recovered sludge contains 99% of water, which may be reduced to 96% by additional settlement of 1 to 3 hours. Over-aeration reduces its volume and also its coagulating properties. Sludge can be dewatered from 96 to 75% by presses without the use of lime, and from 75 to 10% by either indirect steam, or direct heat dryers, without appreciable loss of ammonia. Milwaukee sludge, on a dry basis, contains 4.5 to 5% ammonia. With 4 hours aeration and 2 hours settlement, 8 million gallons of sewage can be treated upon 1 acre. About 80 pages of analytical and other data, and several illustrations accompany the report.

228 **A few figures on the building and operation of the Baltimore disposal plant and notes on the activated sludge experiments.** G. J. REQUARDT. *Proc. Am. Soc. Munic. Impvts.* 23, 416-28. Refers to the activated sludge experiments made in the converted Imhoff tank with the umbrella-like diffuser grids.

229 **A year's progress in activated sludge sewage treatment.** T. C. HATTON. *Proc. Am. Soc. Munic. Impvts.* 23, 404-15. Covers operation, the securing of the activated sludge, aeration, the effects of low temperatures, sedimentation, sludge disposal, and general notes on the Milwaukee experimental work. More fully abstracted from the annual reports, Ref. Nos. 100 and 227.

230 **Discussion of papers on activated sludge.** *Proc. Am. Soc. Munic. Impvts.* 23, 439-43. Covers oral and written discussion of the papers mentioned in references 195, 203, 228 and 229. Participated in by Messrs. HATTON,

COPELAND and NORDELL of Milwaukee; Messrs. FOLWELL, FULLER and POTTER of N. Y. City; MR. E. B. PHELPS of the U. S. Public Health Service; MR. J. R. ELLIS of Regina, Canada; (whose letter describes quite fully the activated sludge experiments in that city); MR. G. L. NOBLE of Chicago; MR. W. T. CARPENTER of Brooklyn; and MR. W. L. STEVENSON of Philadelphia, Pa.

231 **Report of the Committee on Sewage and Sanitation.** G. A. CARPENTER. *Proc. Am. Soc. Munic. Impvts.* 23, 324-6. "It is very generally recognized that the activated sludge method is yet in the process of development, and should not be adopted except under expert advise. Thus far the conditions necessary for success have not been sufficiently standardized to justify the adoption of this method by small communities and the great problem with reference to it today is the question of cost."

232 **Water purification and sanitation.** F. R. O'SHAUGNESSY. *Ann. Report of the Soc. Chem. Ind. of the Progress of Appl. Chem.* 1, 265-7. (1916). A brief general review of the activated sludge process for the year 1916. English plants mentioned are those at Manchester, Worcester, Salford, Stamford and Sheffield. Milwaukee experiments and the work at the Univ. of Ill., Urbana, are the only American plants considered.

233 **Experiments upon the purification of sewage and water at the Lawrence experiment station during the year 1916.** H. W. CLARK. *2nd. Ann. Report Mass. State Dept. Health.* 123-57. Continuation of some of the earlier experiments are recorded, with generally favorable results as shown by the removal of suspended matter, stability, and the tabulated data. A new and larger activated sludge tank was put into operation on the fill and draw plan, allowing 2.5 and 3.5 hours for aeration, 1.5 hours for settlement, and with air supplied at the rate of 0.4 cu. ft. per gallon of sewage, through filtros diffusers, Investigations have shown that the N of the colloids is from 2 to 3 times as great as the N of the coarser solids of the sludge, which fact increases the N content of the sludge about 33%, except in the case of tannery sewage. Investigations of paper mill and tannery trade wastes by the activated sludge process, and several tables of chemical and bacteriological data are included.

234 **Sewerage.** A. P. FOLWELL. (*Book*) Seventh Edition, 468-70. (1916). A brief history and present status of sewage treatment by aeration and the activated sludge process. Refers to experiments at Manchester, Eng., and Milwaukee, Wis.

1917

235 **A new method of purifying tannery and other effluents.** Y. H. GONONIAN. *Leather Manuf.* 28, 45-9. *Chem. Abst.* 11, 1506. A preliminary report in which the author discusses briefly the subject of purification, and then gives a general description of his treatment which involves oxidation, chemical precipitation, and filtration. The crude sewage, screened from coarse materals, is mixed with activated sludge, slowly passed through a septic tank and gravity tank, and fed through a perforated pipe into the top of the filtration and oxidation device. The latter is composed of a series of 5 large superimposed tanks fitted with false bottoms. Under each tank except the last, there passes an endless belt of filter cloth, furnished with scrubbing brushes and washing boxes, which are in turn connected to the settling tanks. Tanks for chemicals are arranged to feed automatically on to the first three filter cloths. The large tanks are partly filled with stones and gravel, the fourth one in the series having a perforated pipe connected to a compressed air or ozone generator for extra aeration when necessary. The first filter cloth is supplied from one of the chemical tanks with a layer of coal ashes, coal, or charcoal; the second with hydrated lime; the third with aluminum sulphate. The effluent in passing through the lime is made alkaline, which

favors the coagulation by the aluminum sulphate on the following cloth. Further aeration in the fourth tank tends to complete the oxidation and precipitation. Diagrams are given.

236 **The activated sludge method of sewage disposal.** E. E. SANDS. *Texas Municipalities* (Jan. 1917) pp. 16-21. A paper presented at the 4th Ann. Conv., League of Texas Munic. held on Oct. 26, 1916, giving a general description of the activated sludge process, and account of the experiments at Houston, Texas, with outline of the proposed plant for that city.

237 **Activated sludge power costs.** G. J. REQUARDT. *Eng. News* 77, 18. *Chem. Abst.* 11, 2517. Curves are given with an explanation of their use for computing the cost of the compressed air which may be required under varying conditions.

238 **Air diffusers for activated sludge.** EDITORIAL. *Munic. Jour.* 42, 11-2. Comments on the merits of filtros plates for that purpose, and considers their proper handling and installation.

239 **Activated sludge process of sewage disposal firmly established.** T. C. HATTON. *Eng. Record* 75, 16-9. *Chem. Abst.* 11, 679. Refers to the several plants in various parts of the country, considers types of sedimentation tanks, air requirements per gallon of sewage treated and its cost, dewatering and drying of the sludge, its costs and value, and emphasizes the importance of complete supervision over the process.

240 **Water supply and sanitary engineering in 1916.** ANON. *Engineer* 123, 32-3. A general review of the progress of activated sludge work during the year. Refers to the Milwaukee plant and the extensive experiments there carried on; to the Salford, Stamford, and Worcester plants in England, and to DR. RIDEAL'S paper on the recovery of N from sewage.

241 **Engineers guide sewage disposal inspection trip.** P. T. HICKS and EDWARD BARTOW. *Eng. Record* 75, 95-7. *Chem. Abst.* 11, 679. Covers the results of an inspection trip by a party from Decatur, Ill., refers to the activated sludge plants at Brooklyn and Cleveland, and comments on the disposal of surplus sludge.

242 **Sewerage and sewage disposal. The activated sludge process.** EDITORIAL. *Surveyor* 51, 80-2. Although few reports on activated sludge work have been published, it is known that the process is operating in about 6 places in England. Reference is made to the plant at Worcester treating 800,000 gallons per day, and belief is expressed that after the war the activated sludge process will be adopted in many places. Utilization of the sludge is also discussed.

243 **Activated sludge progress.** TRADE NOTE. *Surveyor* 51, 108. In collaboration with DR. FOWLER'S staff at Manchester Univ., the engineering staff of JONES & ATTWOOD have been able to make great progress along scientific lines in the activated sludge process. Five large plants have been installed and two are under construction. Diffusers, aeration, sludge settlement and treatment, are being satisfactorily solved.

244 **The activated sludge process of sewage purification.** E. ARDERN. *Jour. Soc. Chem. Ind.* 36, 65-8. *Surveyor* 51, 298-9. *Jour. Am. Leather. Chem. Assoc.* 12, 128-35. *Chem. Abst.* 11, 2517. *Expt. Sta. Record* 37, 286. For the purpose of comparing the effect of trade wastes, the experimental activated sludge plant previously employed on the Manchester sewage—a strong trade sewage—was transferred to the Withington sewage works where a purely domestic sewage is dealt with. The plant consisted of wooden casks of 200 liters capacity. Floating matter and grit was removed from the sewage by adequate detritus tank treatment. Porous tile was used for the air diffusers.

The investigation extended over a period of 15 months with the following summary of results. (1) The activated sludge produced from the Withington sewage has an appreciably higher nitrogen content than either the Manchester or Salford sludge, due to some extent to the fact that the percenage of mineral matter is considerably less. (2) That, contrary to the opinion formed as the result of earlier experiments when working with a strong trade waste, the maintenance of the activity of the sludge is not dependent on the stage to which nitrification is carried. (3) That when dealing with a sewage free from inhibitory trade effluents, no appreciable loss of efficiency need be anticipated in this country (England) during the winter months. (4) That while the problem of sludge disposal remains to be fully developed, it appears from known data that the cost of dewatering and drying will be more than repaid by the value of the resultant dried sludge. Tabulated data and analyses of the dried sludge are given.

245 **Modern sewage treatment.** T. C. HATTON. *Jour. West. Soc. Engrs.* 22, 87-100. A general review of sewage treatment work with special reference to the activated sludge process. Many of the Milwaukee experiments are described, particularly those relating to different methods of aeration, sedimentation and sludge treatment, and a general summary of the results obtained are given. The practical or experimental activated sludge plants in several cities are referred to and their plans or results discussed. The author concludes by expressing his entire confidence in the process because it gives greater promise of satisfactorily solving a complex problem than any other so far introduced.

246 **The purification of sewage in the presence of activated sludge, Illinois.** E. BARTOW, F. W. MOHLMAN and J. F. SCHNELLBACH. *Jour. West Soc. Engrs.* 22, 101-9. (Discussion 109-15). The activated sludge plant at Champaign, Ill., is described. Details are given with special reference to the settling chamber and retention period test, the amount of sewage treated daily during the different periods ranging from 61,100 g. p. d. to 177,600 g. p. d. The authors conclude that 75,000 g. p. d. could be satisfactorily treated with the present aerating and settling capacity, though double this amount could be handled in the aerating tank if additional sedimentation were provided. Sludge dewatering devices are considered. In the discussion following, which included also the paper of MR. HATTON, (Ref. 245) PROF. BARTOW, LANGDON PEARSE, PAUL RUDNICK, and others participated.

247 **The Worcester (Eng.) activated sludge experiments.** T. CAINK. *Surveyor* 51, 144. A letter to the editor to correct a misstatement in a previous article that air was delivered intermittently to the sewage through pulsating valves. This was not the case, the air being delivered continuously throughout the whole period of the experiments.

248 **Brushwood as a medium for sewage filters.** GEO. PHELPS. *Can. Engr.* 32, 117-21. *Eng. Record* 75, 376. *Surveyor* 51, 254-5. *Engineer* 123 337-8. *Am. City* 16, 604-7. *Chem. Abst.* 11, 2517. *Expt. Sta. Record,* 37, 489. A description of the North Toronto, Can., brushwood filter experiments, citing the similarity between the conditions here and those of the activated sludge process. (Cf. Ref. No. 272).

249 **Notes on experiments with activated sludge at Regina, Can.** J. RUSSEL ELLIS. *Can. Engr.* 32, 124-6. Two galvanized-iron tanks 4.5 ft. in diam. by 5 ft. 10 in. deep were used with perforated pipe covered with a loose fitting sleeve of canvas for air diffusion. The plant was operated on the fill and draw plan with cycles of 6 to 12 hours and the results indicate that the process is adapted to local conditions. The size of the plant did not warrant an attempt to determine the cost of operation.

250 **How sewage plants are operating.** ANON. *Munic. Jour.* 42, 196-7. Resume of an inspection trip by officials of Pasadena, Calif., on which several cities were visited where the activated sludge process is in use. The excellent results obtained by this process led them to believe that it will eventually supersede all others where a high degree of purification is necessary. They also find that it occupies less space, costs less for construction, is absolutely odorless, and gives a better effluent than the Imhoff tank and sprinkling filter process. The cost of operation is greater, however, but revenue from the sale of sludge should reduce this difference in costs. They express hope that the sludge may be dried on open beds in a warm climate like southern California. (Cf. Ref. Nos. 210 and 223).

251 **Activated Sludge plants at Houston, Texas.** C. L. WILLIFORD. *Eng. News.* 77, 236-8. Two activated sludge plants with a combined capacity of 19,000,000 gallons a day, with continuous flow aeration tanks, vertical flow settling tanks, and sludge re-aeration tanks are described in considerable detail. One plant consists of four units, the other of two units, each unit having a rectangular aerating tank 280 by 18 feet with a net depth of 9 ft. 9 in., a battery of 10 vertical flow settling tanks and one sludge re-aerating tank. 627 filtros plates are contained in each aerating tank in 112 frames of 6 plates each. The ratio of aeration surface to tank surface is 1 to 7.5. Costs of construction and operation are given.

252 **Activated sludge at San Marcos, Texas.** H. E. ELROD. *Eng. News* 77, 249. Description of a plant having a capacity for treating 150,000 gallons of sewage daily. It consists of an aerating tank 40 by 16 by 8½ ft. deep with four rows of filtros plates in the bottom, and a settling tank 25 ft. long, 10 ft. wide, 25 ft. deep with walls having a vertical batter of 1 to 2. Effluents have a relative stability of 99% and bacterial reduction amounts to 98%. Total cost in round figures was $3,500.

253 **Sink concrete cofferdam in sand for activated sludge plant.** ANON. *Eng. Record* 75, 228-9. Description of work on the activated sludge plant at Escanaba, Mich., which will treat approximately one million gallons of sewage daily on the continuous flow plan. Filtros plates in the ratio of 1 sq. ft. aerating surface to 8.3 sq. ft. tank surface are to be used for air diffusers.

254 **Definitions of terms used in sewerage and sewage disposal practice.** ANON. *Eng. & Contg.* 47, 168-9. *Can. Engr.* 32, 214-6. A report of a committee of the Am. Public Health Assoc., referring to the activated sludge process as in reference No. 202.

255 **Apparatus for aerating sewage and other foul liquids.** R. AMES, Brighton, Eng. British Patent 107,937, Feb. 24, 1917. *Jour. Soc. Chem. Ind.* 36, 977. The sewage is treated in a rectangular tank over which is a traveling carriage running on side rails and bearing a drum with a coil of flexible piping. One end of the piping is connected to an air compressor at the end of the tank, and the end of the drum is connected to a horizontal pipe from which vertical pipes depend nearly to the bottom of the tank. Air diffusers, consisting of porous clay blocks in metal casings, are affixed to the ends of the vertical pipes. The sewage enters at the bottom of the tank through an inverted U-shaped pipe. An air pipe connected to the compressor enters the upward limb of the U-shaped pipe; thus air can be passed into the sewage entering the tank, as well as into the sewage in the tank from the diffusers.

256 **Purification of sewage and other liquids.** W. JONES, Stourbridge, and JONES & ATTWOOD, LT'D., Amblecote, Eng. British Patent 113,333, Feb. 26, 1917. *Jour. Soc. Chem. Ind.* 37, 193A. An improved form of tank for use in the activated sludge process consists of a long channel arranged as the outer coil of a spiral, with air diffusers placed along its length, either in the

middle of the channel or at one or both sides. The floor is made to slope towards the air diffusers. The channel may be restricted in width at each end or at the position of the air diffusers by baffles projecting from the side walls. The channel terminates at the center in a round tank with a conical bottom, not furnished with air diffusers, in which the sludge settles at the bottom and is returned by an air lift or other means to the crude sewage inlet of the channel. Another form of the channel consists of a to and fro rectangular arrangement, with the sludge deposit tank at one end.

257 **Activated sludge tests at Pasadena, Calif.** NEWS ITEM. *Eng. News* **77**, 373. The aerating chamber has a capacity of 50,000 gallons per day with a 4 hour aerating period. There are two settling tanks, a sludge pump and a sludge aerating tank. The tests are in charge of MR. R. V. ORBISON who reports gratifying results and that a plant to handle 3 to 6 million gallons is under consideration.

258 **Worcester's 35-year grapple with sewage disposal problems.** W. L. BUTCHER. *Eng. News* **77**, 384-5. *Chem. Abst.* **11**, 2517. Reviews the history of sewage disposal at Worcester (Mass.) and refers to the contemplated activated sludge experiments.

259 **San Marcos, Texas, activated sludge plant.** G. B. ZIMMELE, *Munic. Jour.* 42, 333-5. *Chem. Abst.* **11**, 1225. This is believed to be the first activated sludge plant to go into regular operation treating the entire volume of sewage of a city. Operations were commenced April 27, 1916. The raw sewage is settled in a tank 40 ft. diam. by 9 ft. deep, with inflow and outflow at different points, which serves to remove the gross material. From this it flows to the aerating tanks, 4 in number, 39 ft. by 4 ft. by 8 ft. extreme depth, and connected in series. Air is diffused through filtros plates set in concrete with special provision for draining the air chamber beneath. Aerating period 2.5 to 5 hours. The sedimentation chamber is 20 ft. by 10 ft. and has a depth of about 25 ft. with bottom slopes of 2 to 1, a period of 1 to 2 hours being allowed for settling. Baffles are also provided in this tank. About 150,000 gallons of sewage are treated daily, from a population of about 5,000. The blower has a capacity of 230 cu. ft. per minute.

260 **Worcester sewage treatment history.** EDITORIAL. *Eng. News* **77**, 406. It is to be hoped that Worcester (Mass.) will give the activated sludge process as full a test as may be needed to determine its suitability for local conditions. The Brockton (Mass.) activated sludge experiments are also referred to.

261 **Operate continuous flow activated sludge plant.** ANON. *Eng. Record* **75**, 380-1. Abstract of article by BARTOW, MOHLMAN and SCHNELLBACH, covered by references 211, 246.

262 **Activated sludge plant for Chicago packinghouse district.** NEWS ITEM. *Eng. News.* 77, 454. An activated sludge plant for treating the sewage and industrial wastes from the Chicago packinghouse district has been recommended by the committee appointed to consider the question. The cost is estimated at $3,500,000 with an annual operating expense of $800,000. The committee was composed of LANGDON PEARSE, Division Eng. of the Sanitary District of Chicago, and DR. W. D. RICHARDSON, chemist for the packinghouse companies.

263 **Experiments relating to the activated sludge process of sewage purification.** W. T. LOCKETT. *Jour. Soc. Chem. Ind.* **36**, 264-9. *Jour. Am. Leather Chem. Assoc.* **12**, 199. *Chem. Abst.* **11**, 2128. Some small scale experiments were made with sewage of "average" strength, which contained a variety of trade wastes, some of them of inimical character. Special attention was given to (1) the volume of air required for the efficient working of

the process, (2) possible means of effecting economy of air, (3) experiments relating to the maintenance of sludge activity and (4) the bacteriological nature of the effluent. The conclusions reached were (1) air in excess of that required for adequate mixture and circulation of the sewage and sludge is of no material advantage. (2) Sludge and sewage in the proportions of 1 : 4 required more air for equivalent results than when the proportion was 2 : 3. Intermittent aeration suggested by MR. W. MAKEPEACE was tried and the fact definitely established that sewage can be purified with reduced expenditure of air by this method, but the time necessary is materially increased and larger tank capacity would be required. The evidence thus far accumulated does not warrant a general recommendation of this method but further experiments are in progress which may eventually have practical importance. (3) Activity of the sludge can be recovered by prolonged aeration, even after standing for several days. (4) Although bacterial removals of 99% and upwards were obtained, and effluents of exceptional clarity and eminently satisfactory from a chemical point of view also obtained, B. *coli* above 1,000 per c. c. were present when the raw sewage was correspondingly high in these organisms.

264 **The activated sludge process.** EDITORIAL. *Surveyor* 51, 297. Commenting upon the paper of DR. E. ARDERN (Ref. No. 244) it is noted that the process adapts itself to the needs of particular cases. Domestic sewage, trade wastes, storm flow, etc., can be handled and the extent to which purification is carried can be adjusted to a nicety. Such conditions indicate the possibility of bringing down operating costs and increasing the application of the process.

265 **The activated sludge process of sewage purification.** E. ARDERN. *Surveyor* 51, 299-300. In the discussion of this paper MR. J. H. HOSEASON, MR. S. E. MELLING, MR. W. THOMPSON and MR. P. GAUNT brought up questions of sludge digestion, possible recovery of the N as sulphate of ammonia, of using peat as a dilutent for the sludge, and the question of more or less complete nitrification on the saving of time in the process.

266 **Activated sludge plant at Edmonton, Canada.** ANON. *Can. Engr.* 32, 265. An account of the plant and the experimental work done at Edmonton, taken from a pamphlet on activated sludge by G. T. HAMMOND. Details of aerating chambers, motor equipment, and air plant are given.

267 **Is the recovery of nitrogen in sewage sludge practicable?** W. R. COPELAND. *Jour. Ind. Eng. Chem.* 9, 374-6. *Jour. Soc. Chem. Ind.* 36, 517-8. *Chem. Abst.* 11, 2008. *Expt. Sta. Record* 37, 425. Summing up the whole situation, dried sludge has a market value of $9 to $15 per ton of material (present figures) with 10% moisture. The total cost of production and placing it on the market will be $8 to $12 per ton, depending on local conditions. Large plants may reduce this cost as a result of further experience.

268 **Biochemical treatment of sewage with special reference to the activated sludge method.** G. T. HAMMOND. *Jour. Ind. Eng. Chem.* 9, 399-403. *Chem. Abst.* 11, 2008. A very concise and complete historical sketch is given on the biochemical treatment of sewage and its newest application in the activated sludge process. Though it is yet in the experimental stage, this method seems very promising. Many problems are yet to be solved, particularly methods of aeration, sludge disposal, and biological control.

269 **Sewage treatment units.** J. W. ALVORD, H. P. EDDY, and G. W. FULLER. *Munic. Jour.* 42, 526. In a report to the North Shore Sanitary District the authors give the following basic data used by them in preparing plans for sewage treatments considered in the report. "Activated sludge—Minimum period of aeration (during maximum rate of flow), 3 hours, 1 2-3 cu. ft. of air per gallon of sewage treated in aerating tanks 15 ft. deep. Sedimentation

tank providing one hour's sedimentation at maximum rate. Sludge storage tank, capacity for 10 days output. Sludge drying bed 3 1-3 sq. ft. per capita; or sludge presses for ¾ to 1 ton of dry sludge per 10,000 people."

270 **Activated sludge vs. tanks and filters.** EDITORIAL. *Surveyor* 51, 359. Comment on paper by H. P. EDDY. (Ref. No. 217). Relative areas of land necessary will govern choice in most cases. Small loss of head in the activated sludge process will be in its favor, as well as the superior quality of the effluent.

271 **The activated sludge process for handling packingtown trade wastes.** LANGDON PEARSE and W. D. RICHARDSON. *Report to the Board of Trustees of the Sanitary District of Chicago.* pp. 36. (April 16, 1917). Suggestions or recommendations include grit chamber, with additional facilities for skimming grease; coarse bar followed by fine screens; aerating tanks in 32 units, each 160 ft. by 38.333 ft. by 16.5 ft. deep, divided longitudinally and of 1.5 million gallons daily capacity; air diffusion through filtros plates, the area of which to the superficial area of the tank is about 1 to 6; air washers to be installed ahead of compressers; continuous flow system with 8 hour contact period and 4 cu. ft. of air per gallon of sewage; settling tanks of the circular Dortmund type, 30 ft. inside diam. with hopper bottom on a slope of 60 degrees, and with a water depth of 33.5 ft.; settling period, 1 hour; sludge handling open to various expedients but from the standpoint of the recovery of values, filter pressing and heat drying only have been demonstrated. Plant cost estimated at $3,751,535, with an annual operating cost of $821,947, of which $270,000 is for power. Revenues expected per million gallons of sewage are:—600 to 1,000 lbs. dry screenings; 47 lbs. grease, and 1,500 to 2,500 lbs. dry sludge. Tables, maps, analytical and other data are given.

272 **The North Toronto brushwood filters.** S. H. ADAMS. *Engineer* 123, 375. *Surveyor* 51, 458. Reference is made to the experiments with brushwood filters and some fundamental differences between this method of sewage purification and the activated sludge process are pointed out. The principal reason for their success in Canada is that their domestic sewage is only about half the strength of that in England. (Cf. Ref. No. 248).

273 **Air diffusion in activated sludge.** W. S. COULTER. *Eng. News-Record* 78, 255-6. *Surveyor* 51, 506-7. *Chem. Abst.* 11, 2008. Experiments indicate the possibility of prolonging the air and sewage contact period by a downward jet entraining air.

274 **Separation and settlement of solids and semi-solids from sewage and analogous liquids.** W. CLIFFORD, Wolverhampton, and JONES & ATTWOOD, L'TD., Amblecote, Eng. Brtish Patent 115,872, May 17, 1917. *Jour. Soc. Chem. Ind* 37, 440A. A tank in the form of an inverted cone is used, into which the sewage is brought by a horizontal pipe, the mouth of which directs the current into a wide bucket suspended in the upper part of the tank. This has the effect of breaking up the currents and causing eddies which pass upwards and out of the bucket. These eddies are prevented from spreading by a guard wall of much larger diameter, surrounding the bucket and carried upwards above the level of the liquid in the tank. The guard wall is open at the bottom, and the liquid passes from it at a low velocity and without any disturbing effect on the deposited sludge in the bottom of the tank. The liquid finally passes out of the tank over a weir at the circumference. The sludge is withdrawn through a pipe in the apex of the cone.

275 **Decanting and settling chemcal and other liquids.** W. CLIFFORD, Wolverhampton, and JONES & ATTWOOD, LT'D., Amblecote, Eng. British Patent 117,472, May 24, 1917. *Jour. Soc. Chem. Ind.* 38, 497A. *Chem. Abst.* 13, 502. In the separation and settlment of suspended matters from chemical and

like manufacturing liquids, providing at or near the top of the settlement tank a bucket or like vessel by which the liquid from the inlet is directed upwardly into a relatively large body of liquid within an open-bottomed guard chamber or well, which directs the slowly moving liquid downward into the body of the liquid in the tank. In a modification, the bucket or like vessel is replaced by a funnel-shaped vessel carried at the end of the inlet pipe, and adapted to direct the flow upwards. (Cf. U. S. Patent 1,343,764. Ref. No. 565).

276 **Marked advance in treating sewage from packinghouses.** G. B. ZIMMELE. *Eng. News-Record* 78, 436-7. *Surveyor* 52, 252. *Chem. Abst.* 11, 2246. *Expt. Sta. Record* 37, 694. An experimental activated sludge plant at Fort Worth, Tex., is equipped with revolving screen and settling tanks, treating packinghouse wastes containing 3000 to 6000 p. p. m. suspended matter. Even when screened and settled, this sewage is too strong for the activated sludge process, and must be diluted with either 4 parts of water or 1 part of treated effluent. 35% sludge during aeration is better than 25%, and separate aeration of the sludge is advisable. The effluent is stable and can be re-used in the packinghouse. The dewatering of the sludge by acidulation and heat has given great promise; this method reducing the water content from 99 to 85%, and increasing the ammonia content from 8 to 11%. (Cf. Ref. No. 291).

277 **The operation of the activated sludge type of sewage plants.** G. B. GASCOIGNE. *Ohio Eng. Soc. Proc.* (1917) pp. 79-86. A general description of the process, the necessary plant, its operation, the sludge dewatering problem, estimated costs, and the method of recording results are given.

278 **Sewage treatment: activated sludge system.** JONES & ATTWOOD, L'TD. *Booklet* No. 52, pp. 18. (June, 1917.) A detailed description of the activated sludge plant at Worcester, (Eng.) covering structural features; air compression, distribution, and diffusers; operating data; degree of purification obtained and running costs. The pulsating gear for supplying air intermittently is described, and some data on the fertilizing properties of activated sludge given.

279 **Report of the city engineer upon an experiment with the activated sludge process of sewage purification.** THOS. CAINK. *Pamphlet* pp. 12. (June 13, 1917.) Deals particularly with the terms between the contractors and the city of Worcester (Eng.), and compares costs of the activated sludge process with that of the old system.

280 **Activated sludge experimental work at Milwaukee.** T. C. HATTON. *Can. Engr.* 32, 491-4. *Chem. Abst.* 11, 3074. Data from the 3rd. Ann. Report of the Milwaukee Sewerage Com. Results of the work are given with details of the sludge pressing experiments. It is concluded that for Milwaukee sewage, the activated sludge process will work with 2 cu. ft. of air per gallon of sewage. With a 4 hour aeration period and 15 to 20% sludge present, 40 to 50 minutes sedimentation is required and a maximum horizontal velocity of 3 ft. per minute, and vertical velocity under 8 inches per minute. Dried sludge contains 4.5 to 5% ammonia.

281 **Activated sludge in India.** NEWS ITEM. *Eng. News-Record* 78, 535. DR. G. J. FOWLER has reported on the possibility of dealing with the sewage of Sakchi, India, a settlement of the Tanta Steel Works with a future population of 150,000, by the activated sludge process.

282 **The activated sludge process at Worcester, (Eng.)** THOS. CAINK. *Surveyor* 51, 546-8. The tests undertaken by JONES & ATTWOOD (Ref. Nos. 172 and 284) were started April 25, 1916. The sewage is screened and grit removed before entering the aerating tanks, which are 18 ft. deep, baffled, and

provided with porous tile diffusers. Aeration period 8 hours, using 0.8 cu. ft. of air per gallon of sewage. Two settling tanks have hopper bottoms with 60 degree slopes, where the sludge is detained for 2.25 hours, being then returned by air lifts. The sludge may be dried on land if applied in layers of one inch, without development of odors. Conditions of tests were fully met. Plant and results are more completely described in a pamphlet issued by JONES & ATTWOOD. (Ref. No. 278.)

283 **The activated sludge process at Worcester, (Eng.)** EDITORIAL. *Surveyor* 51, 544-5. Comment on the paper by T. CAINK (Ref. No. 282), who was responsible for the activated sludge installation. Cost data should be given in detail. Porous plate diffusers are most successful in England.

284 **Activated sludge plant at Worcester, (Eng.)** JONES & ATTWOOD. *Surveyor* 51, 549. *Chem. Abst.* 11, 3074. Complete results of the experimental work at Worcester are given. The tank used was 80 ft. long by 72 ft. wide, divided into 9 longitudinal sections of which 5 were used for aeration and 4 for settling. Air was diffused through porous tiles and no trouble through clogging has been encountered with clean air. The amount of sewage treated on the continuous flow plan varied from 600,000 to 1 million gallons per day. An interesting temperature chart is given, showing sewage, effluent and air temperatures during the winter months.

285 **Apparatus for aerating sewage and other foul liquids.** R. AMES, Brighton, Eng. British Patent 115,933, June 19, 1917. *Jour. Soc. Chem. Ind.* 37, 440A. The sewage enters a channel located alongside a treatment tank, from which it is siphoned into a trough which travels over the tank. The sewage flows into the tank through vertical pipes with bell-mouths, which depend from the trough to the bottom of the tank. Other pipes pass down the centers of the vertical pipes and carry horizontal fans at their lower ends, adapted to revolve inside the bell-mouths, whereby vortices are created and air drawn down the pipes. The blades of the fans are hinged in order to permit of the fans being drawn up the pipes when they require cleaning. A further supply of air is obtained through a pair of tubes extending from the surface to the inside of each bell-mouth.

286 **Recommend 50,000,000 gallon activated sludge plant.** ANON. *Eng. News-Record* 78, 594-6. *Eng. & Contg.* 48, 28-30. *Chem. Abst.* 11, 3074. Joint committee representing the Chicago Sanitary District and the packers recommend a 50 million gallon per day activated sludge plant for treating stockyards sewage, but advise a six months trial of a 1.5 million gallon unit. Digest of the report of PEARSE and RICHARDSON, Ref. No. 271.

287 **Activated sludge bibliography.** NEW LITERATURE NOTE. *Eng. News-Record* 78, 604. *Eng. & Contg.* 49, 354. *Chem. Abst.* 11, 3076. *Expt. Sta. Record* 38, 691. Refers to the first edition of this bibliography.

288 **Milwaukee air-diffusion studies in activated sludge.** C. H. NORDELL. *Eng. News-Record* 78, 628-9. *Chem. Abst.* 11, 2517. The problem is to prolong contact with sewage by subdividing the air into small enough bubbles so that their speed of ascent is lessened. From 25 to 50% of the tank area must be diffusing area or the bubbles will coalesce rapidly. This fact eliminates the use of nozzles and mechanical beaters. Further studies are being made to perfect fine-bubble diffuser plates.

289 **Purification of tannery wastes.** H. B. HOMMON. *Jour. Am. Leather Chem. Assoc.* 12, 320. In discussion of this paper, V. KADISH stated that the activated sludge process had been tried at a chrome tannery in Milwaukee. It worked well with soak liquors and also sulphide liquors if not too concentrated.

290 **Buffalo Meeting of the Am. Inst. Chem. Engrs.** ANON. *Met. & Chem. Eng'rg.* 17, 6. Abstract of a paper on the activated sludge process by DR. E. BARTOW. (Cf. Ref. No. 310.)

291 **Treating packinghouse sewage.** G. L. NOBLE. *Eng. News-Record* 79, 33. A letter to the editor to correct an article by G. B. ZIMMELE, (Ref. No. 276) refuting the statement that the effluent from the activated sludge sewage plant is re-used in the packinghouse like ordinary water. It is also suggested that the statement respecting acid treatment of the sludge, be confined to Fort Worth conditions only.

292 **Sewage aeration and activated sludge.** ANON. *Engineering* 104, 16-17. A general review of the origin and development of the activated sludge process. Refers to the work of BLACK and PHELPS at Brooklyn; CLARK at Lawrence; FOWLER and ARDERN & LOCKETT at Manchester; DUCKWORTH and MELLING at Salford; BARTOW and MOHLMAN at Urbana; HATTON at Milwaukee; NOBLE and RUDNICK at the Chicago stockyards; the plants at Baltimore, Houston, Brockton; and the trial of the process on tannery wastes at Norwood, Mass.

293 **Worcester (Eng.) activated sludge plant.** NEWS ITEM. *Surveyor* 52, 10. The Worcester City Council accepts recommendations made by the water and sewage committee to purchase the activated sludge plant installed by JONES & ATTWOOD for experimental purposes.

294 **Air lifts for activated sewage sludge.** T. CAINK, Worcester, Eng. British Patent 116,580, July 7, 1917. *Jour. Soc. Chem. Ind.* 37, 484A. A vertical pipe is arranged with its lower openings near the floor of the settling chamber, and its upper end surrounded by an annular chamber having a weir at one side over which the sewage flows to another chamber, and thence to the aerating tank. Air is supplied through a small concentric vertical pipe having its lower end terminating in a porous air diffuser, through which the air rises into the lift pipe, carrying the sludge with it. A gage-tube is provided on the annular chamber, so that the height of the liquid over the weir, and consequently the rate of flow, is indicated. The proportion of sludge is indicated by the amount of solid matter settling in the gage-tube.

295 **Activated sludge process of sewage purification at Worcester, Eng.** T. CAINK. *Engineering* 104, 49-51. *Surveyor* 52, 51-5. *Jour. Soc. Chem. Ind.* 36, 938. *Can. Engr.* 33, 30; 38-40. *Chem. Abst.* 11, 3358. A paper presented at the annual meeting of the Assoc. of Mgrs. of Sewage Disposal Wks., July 7, 1917, in which a detailed account of the plant is given, accompanied by designs which show the lay-out and construction. The tank used has a capacity of 626,000 gallons and is divided into 28 rectangular bays, 20 for aeration and 8 for settling. The floor is on the ridge-and-furrow principle with porous tile diffusers in the furrows. These diffusers are placed 5 ft. apart in the first bays of the tank receiving the raw sewage, and 10 ft. apart in the other bays. The floors of the settling bays are in the form of inverted pyramids, in the apices of which are air lifts whereby the sludge is raised to a main which conveys it back to the sewage inlet channel. Excess sludge is drawn off to a sand filter for drying. The purified effluent is decanted from the settling tank. The volume of sewage treated on the continuous flow plan is 750,000 gallons per day, with 8 hours aeration and 2.5 hours settling. The area of the diffusers is about 1-10 the area of the aeration bays, and the volume of air used is 0.8 cu. ft. per gallon of sewage. The sludge when drained, contains 95% water. The analyses of the sewage and effluent are respectively as follows in p. p. m.:—Solids in suspension, 104, trace; solids in solution, 1510, 1430; NaCl, 689, 677; free ammonia, 20, 26; albuminoid ammonia, 5.7, 1.7; O absorbed in 4 hours, 21, 5.6; nitrates and nitrites, none, none. Dissolved O absorbed by the effluent in 5 days, 6.3; stable for 5 days by the incubation test. The standard to which it must conform is that it must be incapable of putrifica-

tion and shall not contain more than 40 p. p. m. suspended solids. This has been met in dry weather, but not with a wet weather flow.

296 **A resume of the present position of the activated sludge process of sewage purification.** E. ARDERN. *Jour. Soc. Chem. Ind.* **36**, 822-30. *Engineering* **104**, 134. *Engineer* **124**, 94. *Surveyor* **52**, 140-2. *Chem. Abst.* **11**, 3357. The paper deals more particularly with typical installations with which the author is familiar, or respecting which authentic information is available. The English plants considered are those at Manchester, Salford, Worcester, and Stamford, while the following American plants are mentioned: Milwaukee, Houston, and the Ill. State Water Survey. A summary of the progress of the method is given, together with intimations of what may be expected in the future.

297 **The activated sludge process.** S. BARWISE. *Surveyor* **52**, 40. Describes the principles involved in this method of sewage treatment, and speculates as to the various methods of applying these in the future; for example, in the form of a new percolating filter.

298 **Activated sludge treatment at Worcester.** (Eng.) EDITORIAL. *Surveyor* **52**, 45-6. Remarks on the paper of MR. T. CAINK (Ref. No. 295) with the intimation that further investigation of the effect of tarry liquids—which upset the plant at Worceser and elsewhere—would be interesting.

299 **Assoc. of Mgrs. of Sewage Disposal Works Meeting.** Discussion of papers. *Surveyor* **52**, 67. Referring to the Worcester activated sludge experiments, MR. T. CAINK describes the incident of large quantities of tarry matter entering the tanks, and interfering seriously with the purification. The O absorption in the sewage rose from 30 or 40 p. p. m. to 140, and in the effluent from 8 p. p. m. to 84. The latter contained only 28 p. p. m. of suspended matter, however, and was stable for 5 days. Antiseptics of this or any other kind should be kept from the sewers, as they operate injuriously against any system of bacterial purification. MR. W. H. DUCKWORTH said that personally he believed there was a great future for the activated sludge process from several points of view, and agreed with Mr. Caink that it was probably not equalled, certainly not surpassed.

300 **Activated sludge process of sewage disposal.** T. CAINK. *Surveyor* **52**, 87-8. Replies to questions raised in connection with the author's paper on the Worcester activated sludge experiments. (Ref. No. 295.) Refers to air requirements, quantity of trade waste in the sewage, contains an estimate of construction and operating charges for a new plant, suggestions for the design of aerating tanks so as to get an efficient flow, and means for removing the sludge.

301 **Activated sludge sewage purification plant near Worcester.** (Eng.) *Engineering* **104**, 118-9. *Chem. Abst.* **12**, 1224. A plant for an Admiralty Airship Station with a population of 400 is described and illustrated. Plans and some tabulated data are given.

302 **Dewatering sludge at Urbana Sewage Station.** ANON. *Eng. News-Record* **79**, 269. Abstract from a portion of a paper on the activated sludge process by DR. E. BARTOW. (Cf. Ref. No. 310.)

303 **Filtros plates made best showing in air diffuser tests.** ANON. *Eng. News-Record* **79**, 269-70. Abstract from a portion of a paper on the activated sludge process by DR. E. BARTOW. Competitors were basswood plates and perforated pipes. (Cf. Ref. No. 310 and 367.)

304 **Apparatus for purifying sewage, etc.** LOCKETT and HERRING-SHAW. British patent applications 11,561; 11,562, Aug. 11, 1917. *Jour. Soc. Chem. Ind.* **36**, Suppl. 79.

305 **Changes in Cleveland sewage plans.** ANON. *Eng. News-Record* 79, 308-12. *Surveyor* 52, 342. *Chem. Abst.* 11, 3358. The activated sludge process is not recommended because of lack of funds, because sufficient treatment for some time to come should be afforded by screening, chlorination, and dispersion of the sewage into the lake through the new submerged multiple outlet pipe, and because valuable local data on sludge handling may be expected in the near future. At some future date the indications are that the activated sludge process should be considered for lake shore sites.

306 **Fine screens or Imhoff tanks?** EDITORIAL. *Eng. News-Record* 79, 290. A consideration of the different recommendations made for sewage disposal at Cleveland, O. The activated sludge experiments and the high hopes expressed for this process are referred to.

307 **The activated sludge process.** EDITORIAL. *Surveyor* 52, 137-8. Comment on the paper by DR. E. ARDERN (Ref. No. 296) in which attention is called to the fact that sewage in most American cities is very weak, the dry weather flow in some cases amounting to 60 to 120 gallons per head, while in English cities it may run from 20 to 50 gallons per head. Therefore, figures given as to cost of air per million gallons of sewage treated in the two countries are very apt to be misleading, and the suggestion is made that a safer method of comparison would be to express such figures in terms of population, say per thousand people.

308 **Purification of sewage and other liquids.** W. JONES, Stourbridge, and JONES & ATTWOOD, L'TD., Amblecote, Eng. British Patent 122,428, Aug. 24, 1917. *Jour. Soc. Chem. Ind.* 38, 197A. *Chem. Abst.* 13, 1734. Sewage is treated with bacterial (activated) sludge and the mixture agitated by the injection of air. The sludge is separated continuously or intermittently from the liquid, and passed to another tank where its activity is intensified by the injection of air, and the active sludge is returned to the treating tank. The separation of the sludge is effected in a series of tanks so arranged that the mixture flows through them at varying rates, and sludges of varying specific gravity are separated and deposited in separate sludge pits connected with the settling tanks. All the operations form a continuous cycle.

309 **Fertilizer.** G. J. FOWLER. Danish Patent 22,389, Aug. 27, 1917. *Chem. Abst.* 12, 512. Air is blown through masses obtained in the purification of sewage in the presence of bacteria. The product is then heated and dried, and then mixed with small quantities of a solid containing bacteria beneficial to plant life, so that the final product contains bacteria favorable to plant growth in addition to large quantities of nitrogen. (Cf. Brit. Pat. 8,397, Ref. No. 51; U. S. Pat. 1,294,080, Ref. No. 454; Can. Pat. 189,921, Ref. No. 467.)

310 **Purification of sewage by aeration in the presence of activated sludge, III.** E. BARTOW. *Jour. Ind. Eng. Chem.* 9, 845-50. *Jour. Soc. Chem. Ind.* 36, 1146. *Jour. Am. Leather Chem. Assoc.* 12, 563. *Trans. Am. Inst. Chem. Engrs.* 10, 159-75. *Chem. Abst.* 11, 3357. Gives further results obtained at the sewage experiment station of the Ill. State Water Survey. A septic tank was reconstructed into an activated sludge tank to handle about 200,000 gallons per day on the continuous flow plan. A bar screen with ¾ in. openings and a two-compartment grit chamber 34 ft. long was provided. The aerating tank is 36½ ft. by 17 ft. by 9½ ft. deep, divided by 3 baffles into 4 compartments, thus giving the sewage a flow of about 140 ft. The settling chamber is 10½ ft. by 6 ft. by 11 ft. deep with sloping walls, and provided with an air lift. Filtros plates supported on T-bars embedded in concrete, in sets of 6, serve as air diffusers. Aerating periods of 6, 5, and 4 hours, treating 144,000, 170,000, and 216,000 gallons respectively, with settling periods of 24, 31, and 37 minutes were tried. About 2 cu. ft. of air per gallon of sewage was necessary to produce a stable effluent. Various modifications of the operating details were tried and the results given in the tabulated data. For comparing different air

diffusers the 3 ft. 2 in. square by 8 ft. deep concrete tanks used in former experiments were employed. (Ref. No. 83.) "A" tank was fitted with perforated pipes having 1-25 in. holes spaced 2 in. apart, and staggered at an angle of 45 degrees from the top of the pipe. "B" tank contained basswood blocks covering an area of 1 ft. 3 9-16 in. by 2 ft. 3 in. "C" tank contained 3 sq. ft. of filtros designated as "fine," and "D" tank 3 sq. ft. designated as "coarse." These tanks were operated during three periods of 15, 20, and 35 days, all conditions being maintained as nearly identical as possible. The results obtained from these comparative tests indicate the superiority of filtros, with little if any difference between the two grades. In the sludge dewatering experiments drying on sand beds was not satisfactory, nor did filter pressing give a good cake even with a fairly concentrated sludge. The Koering rotary pressure drum filter gave unsatisfactory results on the first trial, further tests being prevented by an accident. Experiments with a modified basket type of centrifuge and a cream separator were encouraging, but a specially constructed centrifuge, designed by the Tolhurst Machine Works, gave the best results and indicated that a large machine would reduce the water content of the sludge to about 88%. Drying tests pointed to a practical way of dewatering further.

311 **Some characteristics of the activated sludge process of sewage treatment.** A. L. FALES. *Munic. Engrg.* 53, 108. *Can. Engr.* 33, 230. A general discussion of the process giving the following requisites as essential for the successful treatment of sewage by this process. (1) Correct amount of bacterially active sludge; about 25%. (2) Supply of oxygen to promote growth; about 1.75 cu. ft. of air per gallon of sewage. (3) Proper aeration period; about 4 hours for ordinary sewage. (4) Optimum temperature for bacterial action.

312 **Comparative tests of air diffusers and devices for dewatering activated sludge.** ANON. *Eng. & Contg.* 48, 217-20. *Can. Engr.* 33, 339-41. *Chem. Abst.* 11, 3074. Abstract of a paper by DR. E. BARTOW presented at the Buffalo meeting of the Am. Inst. Chem. Engrs. Filtros plates, perforated pipes and wood blocks were tried, filtros proving most satisfactory. Centrifuges reduced the moisture content of the sludge to 85-88%. (Cf. Ref. Nos. 310 and 367.)

313 **Jersey City water supply clean-up proposed.** NEWS ITEM. *Eng. News-Record* 79, 522. Diversion of sewage below Boonton dam with activated sludge plant and chlorination recommended.

314 **Apparatus for aerating sewage.** GRIFFITHS & HARTLEY. British Patent Application 13,374, Sept. 18, 1917. *Jour. Soc. Chem. Ind.* 36, Suppl. 95.

315 **Activated sludge plant proposed.** NEWS ITEM. *Munic. Jour.* 43, 291. To treat the sewage discharged into the Rockaway river, the activated sludge process is recommended for the reasons stated by G. A. JOHNSON, that the effluent obtained will be highly satisfactory as far as physical and chemical characteristics are concerned. Low electric power cost and the possibility of disposing of the sludge at a profit, justifies its adoption on economic grounds.

316 **Brockton (Mass.) activated sludge plans.** NEWS ITEM. *Eng. News-Record* 79, 551. Plans for the proposed activated sludge plant are being made by H. S. CROCKER, city engineer, but will probably not be sufficiently advanced for bids until 1918. Plant will have a capacity of 3 million gallons daily, with a 4 hour running-through period.

317 **Fifty million gallon plant recommended for Chicago stockyards.** EDITORIAL. *Surveyor* 52, 253. Abstract of a pamphlet issued by the Sanitary District of Chicago (Ref. No. 271) containing the report and recommendations of RICHARDSON and PEARSE for a 50 million g. p. d. activated sludge plant for Packingtown.

318 **The treatment of trade wastes.** EDITORIAL. *Surveyor* 52, 246. Mentions successful experiments for treating very strong packinghouse wastes at Fort Worth, Texas, by the activated sludge process, and comments on the proposed 50 million plant at the Chicago stockyards.

319 **Various methods of dewatering activated sludge.** DR. E. BARTOW. *Munic. Eng'rg.* 53, 148-9. Sand beds, filter presses, the Koering rotary drum, and centrifuges were considered. (Cf. Ref. No. 310.)

320 **Experiments on sewage purification by the activated sludge process.** A. CRONIN. *Austral. Pharm. Notes* (Oct. 1, 1917) 18-20. *Jour. Soc. Chem. Ind.* 37, 106A. *Chem. Abst.* 12, 2033. The first trial was made at Sydney, Aust., in 1916, the plant consisting of 3 wooden tanks of 500 gallons capacity each, air being supplied through perforated pipes covered with broken stone. Two of the tanks were seeded with sludge from contact beds, but this method proved a failure. In the third tank raw sewage was treated in the usual way, 3 days aeration being followed by 15 hours settling. Analyses made after 2, 3, and 4 months working gave practically concordant results, the purification being about 99% in suspended solids, 92% in organic N, and 84% in O absorption. All the effluents were stable by the methylene blue test and no odor was given off during treatment. A larger tank of 10,000 gallons capacity was then constructed of concrete, and has been in continuous operation since Nov., 1916, on the fill and draw plan. The aeration period at starting was 4 days, then 3 days, then 20, 10, 7, 6, and 5 hours. After 8 weeks the accumulated sludge occupied 20-25% of the capacity of the tank. 5 hours aeration did not give good results, so after 6 months operation the aerating period was fixed at 6 hours with 2 hours settling. Purification was 96% in suspended solids, 87.7% in organic N, and 86.3% in O absorption. The effluent was odorless but had a faint "peaty color," and was stable after the first three weeks working. Air used was 4.8 cu. ft. per gallon of sewage. The sludge contained 66% (?) of moisture and dried readily on sand. An analysis calculated to 10% moisture showed total N, 3.2%; phosphoric acid, 2.7%; potash, 0.35%.

321 **Comparative tests of air diffusers.** ANON. *Surveyor* 52, 528. The results of competitive tests of wood blocks, perforated pipes and filtros plates, indicated the superiority of the latter. From DR. E. BARTOW'S paper, reference No. 310.

322 **Activated sludge process for the Stockyards.** ANON. *Munic. Jour.* 43, 377-9. Digest of the report of PEARSE and RICHARDSON on the proposed activated sludge plant for treating packinghouse wastes. (Cf. Ref. No. 271).

323 **Machinery in sewage treatment.** EDITORIAL. *Munic. Jour.* 43, 381. Comments on the report of PEARSE and RICHARDSON on the 50 million gallon plant proposed at Chicago, and points out the large amount of machinery required in the activated sludge process as compared with other methods, as well as the skill required for its operation.

324 **Removal of activated sludge.** T. C. HATTON. *Munic. Jour.* 43, 382. *Surveyor* 52, 445. A Dorr thickener was used in a 13 ft. diam. tank, removing the sludge continuously to a central draw-off, and promises to be successful. The sludge is prevented from settling on the slopes of the hopper bottom and becoming septic.

325 **Preliminary treatment of sewage: fine screens.** EDITORIAL. *Surveyor* 52, 333. It is mentioned that the activated sludge process was given due consideration at Cleveland, O., but was rejected as not suitable under present existing conditions.

326 **Notes on activated sludge with particular reference to the treatment of packinghouse wastes.** LANGDON PEARSE. *Can. Engr.* 33, 358-9. A paper presented at the meeting of the Am. Pub. Health Assoc. on Oct. 18, 1917. The sewage testing station of the Chicago Sanitary District is described, and the results obtained up to March, 1917, show that the sewage should be screened through 30 mesh, as it will then by 8 hours aeration produce a stable effluent in summer with 4 cu. ft. of air per gallon, in tanks 16.5 ft. deep. 6 cu. ft. of air or more, may be required in cold weather to produce equivalent stability. Air distribution was through filtros plates set in cast-iron boxes; ratio, 1 to 6. Recoveries per million gallons of sewage were as follows:—Grease as scum, 360 lbs.; as grease, 47 lbs.; screenings, dry basis, 600-1000 lbs.; sludge, dry basis, 2000-3000 lbs. Requirements for Fort Worth, Texas, packinghouse sewage plants are compared with those for Chicago. The arrangement and design of the tanks; methods of baffling, agitation, and air distribution; sludge settling and treatment, touching on the effect of acid on activated sludge from different sources; and stability of effluent are considered. The plants herein referred to have been remarkably free from odor. Typical analyses of sewage, screenings, and sludge are given, and the author expresses the opinion that the activated sludge process offers the best promise of treating packinghouse wastes, and recommends a unit plant of 1.5 million gallons daily capacity, so as to obtain large-scale working results. (Cf. Ref. Nos. 271, 327, 337 and 371).

327 **Activated sludge to solve packinghouse wastes problem.** LANGDON PEARSE. *Eng. News-Record* 79, 777-8. *Chem. Abst.* 12, 75. At Chicago, 4 cu. ft of air per gallon of sewage in summer, and 6 cu. ft. in winter, is sufficient to stabilize the effluent. Filtros plates appears to be the best material for air diffusion, though perforated pipes were tried but they required more air. The ratio of gross area of filtros plates to tank area at Chicago was 1 to 6.3; net area 1 to 8. At Fort Worth, Texas, 1 to 7 has been used. Settling period may be 0.5 to 1 hour, and bottom slopes should be 60 degrees from the horizontal. Velocities should be low. For 9 months, with screened sewage, about 46,500 gallons of liquid sludge having 99.2% water, was obtained per million gallons of sewage, which is equivalent to 2,420 lbs. of dry solids. The screenings, on 30 mesh, varied from 500 to 1,200 lbs. of dry material. Plain sedimentation reduces considerably the moisture content of the sludge, which contains on a dry basis from 5 to 6% N, with an estimated value of $12 to $18 per ton. (Cf. Ref. Nos. 271, 326, 337 and 371).

328 **The treatment of sewage by aeration and activated sludge.** ANON. *Engineering* 104, 444. *Chem. Abst.* 12, 1224. Comments on efficient air diffusion and aeration; the progress of the activated sludge work in America, with special reference to Milwaukee; the work at Sheffield, Eng.; and on DR. E. ARDERN'S paper. (Ref. No. 296). Operating costs and sludge treatment are discussed, including the DICKSON yeast process of dewatering.

329 **New Haven (Conn.) tests five processes of sewage treatment.** F. W. MOHLMAN. *Eng. News-Record* 79, 829-30. *Engineer* 125, 97. Respecting the activated sludge process, the experiments were carried out on the continuous flow plan in tanks 16 ft. by 4 ft. by 8 ft. deep, with filtros plates set in cast-iron frames as the air diffusers. 17,000 gallons are treated daily, allowing 3 hours for aeration and 66 minutes for settling. (Cf. Ref. No. 338).

330 **Sewage purification. L. G. B. requirements and other data.** S. H. ADAMS. *Pamphlet* pp. 6. (Nov. 1917). A brief general description of the activated sludge process, and some data from the Milwaukee experiments, occupy one page.

331 **How the activated sludge process of sewage disposal is working in Pasadena.** R. V. ORBISON. *Pacific Municipalities* (Nov. 1917) 594-606. A description of the testing station, the process, and a brief summary of the results obtained. Treatment cost estimates and a consideration of the possible revenues from the process are given. (Cf. Ref. 349).

332 **Clearing house summary on activated sludge.** EDITORIAL. *Eng. News-Record* 79, 817. Comment on T. C. HATTON'S paper. (Ref. No. 333). "In a large sense, Milwaukee has been a clearing house for activated sludge data and opinion, for nearly everyone interested in the process has visited the Milwaukee testing station or at least has corresponded with Mr. Hatton. —The initial work at Lawrence and its elaboration by DR. GILBERT J. FOWLER and his followers in England, should never be lost sight of by those who desire to give credit where credit is due."

333 **Conclusions on the activated sludge process at Milwaukee, Wis.** T. C. HATTON. *Eng. News-Record* 79, 840-4. *Surveyor* 53, 232-3, 254-5. *Chem. Abst.* 12, 75. Mr. Hatton's paper before the Am. Public Health Association in October, 1917. When sewage is treated 1 hour with 0.5 cu. ft. of air per gallon in an aerating tank of 15 ft. effective depth, a 98% removal of suspended matter is obtained, but for complete nitrification 0.75 to 1.1 cu. ft. of air per gallon must be applied 4 to 6 hours. To prevent clogging of the air diffusing plates, grit chamber treatment is necessary when storm water is mixed with the sewage, and preliminary treatment with fine screens is recommended for sewage from industrial communities, while for purely domestic sewage, 3-16 in. slotted screen is sufficient. About 20% of well activated sludge is necessary for satisfactory treatment. The sludge as withdrawn from the aerating tanks contains 99 to 99.5% water, which is reduced to 96% by 5 to 6 hours settling. Presses and driers can be used to lower the water content to 10%. Typical analysis of dried sludge shows 5.1% ammonia, 5.3% fat, 0.5% soluble phosphorus pentoxide, and 0.25% potassium oxide. Flies, insects, and worms do not infest the treatment plant, nor is any offensive odor connected with the process.

334 **The activated sludge method of sewage treatment.** F. W. MOHLMAN. *Univ. Ill. Bull.* 15, 75-113. (Water Survey Series No. 14). *Abst. Bact.* 2, 149. *Pamphlet* pp. 43. "1. In the aeration of sewage there is almost quantitative oxidation of ammonia N to nitrite N, followed by oxidation to nitrate N. From 10 to 20 days are required. In the aeration of sewage in contact with activated sludge, ammonia N is oxidized to nitrate N in from 4 to 5 hours. Nitrite N is evidently oxidized to nitrate N almost as rapidly as it is formed. 2. Satisfactory activated sludge can be obtained with 6 hour aeration periods without complete nitrification from the beginning of the operation. 3. In a small tank the equivalent of 1,300 lbs. of dry sludge per million gallons of strong sewage was obtained. In larger tanks 740 to 1,150 lbs. of dry sludge per million gallons of average sewage were obtained. 4. In the presence of 25% sludge, weak sewage was well nitrified in 4 hours with 1 cu. ft. of air per gallon of sewage. Normal sewage required 4-5 hours aeration and 1.3 cu. ft. of air per gallon of sewage. Strong sewage required more than 5 hours aeration and more than 1.5 cu. ft. of air per gallon of sewage. 5. Better results were obtained when 1-3 the floor surface was covered with porous plates, than when all or 1-9 of the floor surface was covered. 6. The N in the sludge increases by from 0.5 to 1.5% per day until an average of 5.1% N is obtained. 7. The content of phosphoric pentoxide varies in the same way as the N, reaching an average of about 3%. 8. Dewatering the sludge is a problem which has not yet reached a satisfactory solution, although small scale experiments with centrifuges have given promising results. It has been practically impossible to obtain a solid cake by filter-pressing the activated sludge and experiments with precipitants and filtros-plate filters also gave unsatisfactory results." The above is the author's summary of the article.

335 **Decomposition products of sewage disposal.** F. N. CRAWFORD. *Univ. Ill. Bull.* 15, 162-8. (Water Survey Series No. 14). *Abst. Bact.* 2, 149. A study of the effluent gases in the activated sludge process. Author's conclusions:—"Aeration of tap water, of sewage, and of sewage in the presence of activated sludge, yield quantities of carbon dioxide and of O which are

greatly at variance. (1) Tap water containing bicarbonates, when aerated undergoes a loss of carbon dioxide, the partial conversion of bicarbonates to normal carbonates, and the establishment of dissolved O at the normal for water saturated with atmospheric gases. (2) Sewage alone undergoes similar changes; the extinction of free carbon dioxide; partial conversion of bicarbonates to normal carbonates, and dissolved O slightly less than the normal for air-saturated water. (3) Sewage with activated sludge similarly aerated yields increasing quantities of carbon dioxide as the sludge builds up, while the bicarbonate alkalinity remains unchanged. The increment of carbon dioxide appearing in the effluent gases collected during aeration of the sewage with activated sludge is derived from biological fermentation of carbonaceous matter." (Cf. Ref. 158).

336 **Bacterial purification of sewage.** W. F. KAMM. *Univ. Ill. Bull.* 15, 146-61. (Water Survey Series No. 14). *Chem. Abst.* 12, 1674. *Abst. Bact.* 2, 149. Conclusions:—"(a) Denitrifying bacteria reduce the nitrate and nitrite in sewage. (b) They are constantly present in sewage, but their action is often overlooked because of the greater amount of nitrification. (c) In all the aeration experiments a large amount of N (as ammonia) is lost. (d) The denitrifying action (under certain conditions) predominates over the nitrifying action and may be the cause of the failure to nitrify the sewage in some aeration tanks. (e) Denitrifying organisms play an essential role in the purification of sewage by aeration in the presence of activated sludge." Numerous diagrams accompany the article.

337 **The treatment of packinghouse wastes by the activated sludge process.** ANON. *Eng. & Contg.* 48, 386-8. Practically the full paper presented by LANGDON PEARSE at the meeting of the Am. Public Health Assoc. on Oct. 18, 1917. (Cf. Ref. Nos. 271, 326, 327 and 371).

338 **The sewage experiment station at New Haven, Conn.** ANON. *Eng. & Contg.* 48, 390-1. The activated sludge experiments were on the continuous flow plan in an aerating tank 16 by 4 by 8 ft. deep, with a bottom sloping at 45 degrees to a trough 1 ft. wide, in which were placed 15 filtros plates as air diffusers. The settling tank is 4 by 4 by 12 ft. deep to the bottom of the hopper. Aerating tank has a capacity of 3,100 gallons and is treating 17,000 gallons of sewage daily with a 3 hour aeration period. Settling tank has a capacity of 1,150 gallons, and the settling period is 66 minutes. (Cf. Ref. 329).

339 **Papers on activated sludge.** NEWS ITEM. *Eng. News-Record* 79, 940. Refers to reprints of papers by DR. E. ARDERN which are available. These reprints cover articles noted in Ref. Nos. 244 and 296.

340 **Nature of activated sludge.** F. DIENERT. *Comptes rend.* 165, 1116-7. *Jour. Soc. Chem. Ind.* 37, 71A. *Chem. Abst.* 12, 1224. To prepare activated sludge from Paris sewage it was found necessary to aerate the sewage for 30 hours to effect nitrification of the 10 mgrs. of ammonia per liter which it contained. The liquid was then decanted, a further volume of sewage admitted to the residual sludge, and aeration continued. These operations were repeated for 15 to 20 days, when the time required for nitrification had been reduced to 1.5 hours, and the volume of the sludge had much increased. During the aeration the dissolved carbon dioxide is expelled and the calcium bicarbonate precipitated as carbonate; at the same time the precipitate removes some of the suspended and dissolved organic matter by absorption. It was found that the alkalinity of the sewage was reduced from 180 to 60 parts of lime per million, by 1.5 hours aeration. The activated sludge contained 50% mineral matter, chiefly calcium carbonate; 20% of albuminoid matter, and 30% of non-albuminoid matter. In tests in which the sewage took 2 hours to travel along the sewers, it was found that in consequence of the aeration which took place during that time, that about three-quarters of the albuminoid and ammoniacal matter was absorbed by the precipitated calcium carbonate, and was found in the deposits of same along the sewers.

341 **Purification of sewage and analogous liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,247,540, Nov. 20, 1917. (Application filed Oct. 9, 1914. 16 claims). *Off. Gaz.* 244, 774. *Jour. Soc. Chem. Ind.* 37, 38A. *Chem. Abst.* 12, 397. Claim 3:—The process of treating sewage or the like, consisting in causing a local upflow in the liquid, and supplying air locally into the liquid in its flow; causing the sludge and solid matters to pass to a point of the part of the flow which is being supplied with air; and removing the clarified liquid from the body. Claim 5:—The process of treating sewage or the like, consisting in causing an up and down flow, and a lateral flow in the liquid, the lateral flow being from the upper part of the upflowing part of the liquid, and supplying air into the liquid in its flow. (Cf. Brit. Pat. 22,952. Ref. No. 3).

342 **Purification of sewage and other liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,247,541, Nov. 20, 1917. (Application filed Sept. 13, 1915. 6 claims). *Off. Gaz.* 244, 774. *Jour. Soc. Chem. Ind.* 37, 38A. *Chem. Abst.* 12, 397. Claim 1:—The process of purifying sewage or other impure liquid by supplying the sewage or impure liquid to a tank, supplying or delivering air in small bubbles periodically a plurality of times at different points to the liquid in the tank during its treatment, until it is purified, and running off the purified liquid. (Cf. Brit. Pat. 1,141, Ref. No. 33 and Can. Pat. 183,586, Ref. No. 402).

343 **Purification of sewage and analogous liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,247,542, Nov. 20, 1917. (Application filed Oct. 18, 1915. 9 claims). *Off. Gaz.* 244, 774. *Jour. Soc. Chem. Ind.* 37, 38A. *Chem. Abst.* 12, 397. Claim 4:—The process of purifying sewage or analogous liquids, consisting in supplying crude sewage or liquid, causing it to flow while being treated, delivering air into the liquid in the presence of bacterial sludge or solid matter, depositing the sludge at a point of its flow removed from that where the aeration or oxidation is taking place, and transferring the deposited sludge or solid matters to the sewage or liquid in the aerating or oxidizing portion. (Cf. Brit. Pat. 22,737, Ref. No. 18).

344 **Purification of sewage and analogous liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,247,543, Nov. 20, 1917. (Application filed Oct. 18, 1915. 6 claims). *Off. Gaz.* 244, 775. *Jour. Soc. Chem. Ind.* 37, 38A. *Chem. Abst.* 12, 397. Claim 5:—The process of purifying sewage or analogous liquids, which consists in aerating or oxidizing a plurality of quantities of liquid in the presence of bacterial sludge, depositing sludge or solid matters therefrom, transferring the sludge in which the bacteria have deteriorated or weakened to tanks, aerating or oxidizing the removed and debilitated sludge and so recuperating it, and transferring the recuperated sludge to one or more of the bodies of the liquid being treated. (Cf. Brit. Pat. 22,736. Ref. No. 17).

345 **Handling sludge from activated plants.** ANON. *Munic. Jour.* 43, 508. Conclusions from operation of the test plants at Chicago and Fort Worth, Texas. Acid acts differently on the two sludges. Plain settling has considerable value in reducing moisture content, but effectiveness varies with the condition of the sludge. Improvements in settling tanks, other devices as the Dorr tank, the use of coagulents, filter pressing, etc., should be studied with a view of more effectively reducing the water content of activated sludge.

346 **Sewage disposal for Indianapolis, Ind.** ANON. *Munic. Jour.* 43, 510. A report on the application of modern methods of sewage treatment to the conditions at Indianapolis, made by G. W. FULLER to the sanitary commission of that city, considers in some detail the Imhoff tank, the activated sludge, and the fine screen methods of treatment, concluding in favor of

the last. The report refers to the large installations of Imhoff tanks and their difficulties, and to the large experimental activated sludge plants, but is not encouraging as to the efficiency of either. (Cf. Ref. No. 347).

347 **Screens, filters and humus tanks for Indianapolis, Ind.** ANON. *Eng. News-Record* 79, 972-4. *Chem. Abst.* 12, 395. This method of sewage treatment has been recommended by G. W. FULLER after considering also, Imhoff tanks with sprinkling filter, and the activated sludge process. It is stated, however, that the activated sludge process is the cheapest one to install and that it would produce the most complete purification, but in comparing its status at Indianapolis with its suitability elsewhere, recognition should be given to the fact that there would be no saving in the purchase of site or in construction of intercepting or outfall sewers by locating this compact type of plant nearer the city. (Cf. Ref. No. 346).

348 **Many activated sludge plants.** NEWS ITEM. *Eng. News-Record* 79, 987. About 25 experimental activated sludge plants have been built in various parts of the world, according to a paper read recently by MR. T. C. HATTON before the Am. Pub. Health Assoc. Of these one was in India, 7 in England, and 14 in the United States. Seven treatment plants have been built in the United States, and 4 more of considerable magnitude are proposed.

349 **Activated sludge tests made by California cities.** ANON. *Eng. News-Record* 79, 1009-10. *Chem. Abst.* 12, 395. Description of experimental plant and result of tests made at Pasadena, Calif., under the direction of R. V. ORBISON. The aerating tank is 20 by 9 by 10 ft. deep, with two lengthwise partitions giving a 60 ft. continuous channel, in which 21 filtros plates are located. Ratio 1 to 8.5. Two settling tanks were built but only one used. A sludge reaerating tank 12 by 6 at the top, 12 by 2 at the bottom, and 10 ft. deep, equipped with 4 filtros plates is in use. 4 hours aeration using 1 cu. ft. of air per gallon of sewage, with 10-20% activated sludge, followed by 30 minutes settling, gives a non-putrescible effluent, containing nitrates, and a bacterial reduction of 96 to 99.6%. Other aeration periods and air volumes were tried. Sludge drying in open beds gives rise to odors that make this means impossible. The daily flow from the 3 cities interested (Pasadena, South Pasadena and Alhambra) is about 3 million gallons, normal; 7.5 million gallons, maximum. Testing plant handles 50,000 gallons daily on an area of 267 sq. ft., or the equivalent of 8 million gallons per acre on a 4 hour aeration basis. It is estimated that the activated sludge process would save at least 50% on the construction cost of Imhoff tanks with necessary accessories. (Cf. Ref. No. 331).

350 **Activated sludge.** THOS. CAINK. *Surveyor* 52, 471. In a communication to the editor it is stated that because of its buoyant nature, the sludge will not flow down sloping sides. Scrapers on flat-bottom tanks were first recommended by the author in his paper in The Surveyor 52, 51-2. July 20, 1917. (Ref. No. 295).

351 **Worcester, (Mass.) activated sludge experiments.** M. GAULT. *Ann. Report. Supt. Sewers for year ending Nov. 30, 1917.* 697-731. Refers to the 100,000 gallons experimental activated sludge plant which begun operations July 7, 1917. Results to be reported when experiments are completed. (Cf. Ref. No. 487 and 540).

352 **Sewage disposal in Kansas.** F. M. VEATCH, H. P. EVANS and L. E. JACKSON. *Bull. Univ. of Kansas*, 18, 30. A brief general description of the activated sludge process is given.

353 **Some conclusions reached at Milwaukee on the treatment of sewage by the activated sludge process.** ANON. *Munic. Eng'rg.* 53, 243-6. Results

of observations and studies of operation of the sewage testing station. From a paper by T. C. HATTON presented at a meeting of the Am. Public Health Assoc. (Cf. Ref. No. 333).

354 **Copper in sewage at New Haven Experiment Station.** F. W. MOHLMAN. *Jour. Ind. Eng. Chem.* 9, 1093-6. Refers to the activated sludge plant and experiments as in references Nos. 329 and 338.

355 **Pressing sewage sludge.** ANON. *Can. Engr.* 33, 473-4. *Munic. Jour.* 44, 14-6. *Eng. & Contg.* 49, 165-8. *Chem. Abst.* 12, 842. Abridgement of a paper by KENNETH ALLEN read at the 1917 meeting of the Am. Soc. Munic. Impvts., in which activated sludge is referred to only as in reference No. 365.

356 **Are fine screens needed for the activated sludge process?** G. B. GASCOIGNE and T. C. HATTON. *Eng. News-Record* 79, 1072-3. Letters to the editor in which the first author questions the necessity for fine screens as preliminary to the activated sludge process: answered by the second author to the effect that they insure a more satisfactory operation of the plant. Essentially a discussion as to the merits of coarse and fine screens at Cleveland and Milwaukee respectively.

357 **Cleveland sewage screen plans withdrawn from State Dept. of Health.** ANON *Eng. News-Record* 79, 1128. City will submit plans for screens and activated sludge plant, and request that construction of the latter be postponed until screens have been operated for one year.

358 **California sewage plants are neglected.** ANON. *Eng. News-Record* 79, 1127. Refers to sewage plants in general but notes that the new activated sludge plant at the Folsom state prison has recently been put into operation to handle the sewage produced by 1,500 inmates. Ordinary objections to power costs do not pertain here as the prison generates its own power. (Cf. Ref. No. 567.)

359 **The real issue as to sewage plans at Cleveland.** EDITORIAL. *Eng. News-Record* 79, 1085. Intimates that the local conditions may compel the city to treat its sewage by activated sludge process.

360 **Activated sludge system of sewage purification at Worcester, Eng.** ANON. *Sanitary Record* 59, 393. *Chem. Abst.* 11, 3357. The cost of power for aerating sewage and sludge is 32s per million gallons, when the rate is 750,000 gallons per day. Average analyses of 12 samples of effluent, covering a 12-month period was:—Suspended matter 7.2; albuminoid ammonia, 1.4; O absorbed in 4 hours, 5.6 p. p. m. Porous tile seems to diffuse the air better than mechanical diffusers. A reduction of 50% of the air used is obtained by the use of a patent pulsating gear (Ref. No. 33) which supplies the air in puffs, resulting in better circulation. Experiments with activated sludge as fertilizer showed an increased yield of potatoes of 100% over those to which barnyard manure was applied.

361 **The activated sludge process.** EDITORIAL. *Surveyor* 52, 527. Comment on DR. E. BARTOW'S article on air diffusers (Ref. No. 321) in which it is noted that porous tile diffusers are more satisfactory in America as well as in England.

362 **Investigations in regard to purification of sewage and water at the Lawrence experiment station during the year 1917.** H. W. CLARK. *3rd. Ann. Report State Dept. of Health, Mass.* 122-72. *Munic. Jour. Pub. Works* 47, 345-6. *Chem. Abst.* 14, 1174. During 1917 the tanks containing layers of slate remained in operation, and new and larger activated sludge tanks were started. Briefly summarizing the extensive studies, it may be noted that sewage of different characters and strengths require very different aerating

periods and air volumes for satisfactory results, and unless these are employed in excess, a modified, rather than a purified sewage results. The quality of the sludge, physically and chemically, appears to be of vital importance, and too much can be used. In certain experiments the amount of O required for sewage oxidation was found to be 350 pounds per million gallons, whereas activated sludge at 2 cu. ft. of air per gallon, required 100 times this amount to stability. Studies on the destruction of organic matter by oxidation; the effect of sterilizing chemicals on activated sludge; (mercuric chloride stops its action completely) and of the progressive flow through activated sludge and other tanks (Ref. No. 434) are noted in this report, as well as numerous tables of analytical data.

363 **Syracuse, N. Y., tests two methods of sewage treatment.** ANON. *Eng. News-Record* 79, 1201-2. *Chem. Abst.* 12, 730. The activated sludge installation embraces an aerating tank 12 by 4 by 10 ft. deep, and 1 inch pipes with 1-16 inch perforations 3 inches center to center, distributes the air. Settling tank is 4 ft. square, maximum depth 15 ft., with 4 to 1 sloping bottom. From this tank an air lift delivers the sludge back to the aerating tank or to a sludge re-aerating tank, also 4 ft. square. (Cf. Ref. No. 378.)

364 **The disposal of sludge.** DISCUSSION. *Surveyor* 52, 552-3. Various practices are discussed at the annual meeting of Mgrs. of Sewage Disposal Works. Mention is made of the fine screens used successfully at the Milwaukee activated sludge plant.

365 **The pressing of sewage sludge.** K. ALLEN. *Trans. Am. Soc. Munic. Impvts.* 24, 1-25. A tabulation of the properties and quantities p. m. g. of the various sludges is given, including activated sludge. The Berrigan or Worthington press at Milwaukee, with activated sludge, reaches an ultimate pressure of 60 lbs. per sq. in., and produces 5 tons of cake per 24 hours, having a moisture content of 75%. Estimated cost of operation is $3.46 per ton of cake. MR. G. W. FULLER estimates the cost of pressing activated sludge at about $3.00 per ton of dry solids, or $2.70 per ton with 10% moisture. PEARSE and RICHARDSON (Ref. No. 271) estimate the cost of pressing sludge from stockyards sewage at $5.72, based on 96 tons of dry material daily. In the discussion following, (pp. 57-62, 81-96) reference was made to sludge from the activated process by C. E. A. WINSLOW, R. S. WESTON, G. B. KERSHAW, and F. A. DALLYN.

366 **Water purification and sanitation.** S. RIDEAL. *Ann. Reports Soc. Chem. Ind. on the Progress of Appl. Chem.* 2, 461-3. A brief general review of the activated sludge process is given for the year 1917. English plants referred to are: Manchester, (Withington works) Salford, Worcester, Stamford, Lincoln, and Sheffield. American plants mentioned are: Milwaukee, Houston, Fort Worth, and Chicago.

367 **Tests of air diffusers for the activated sludge process.** E. BARTOW and F. L. MICKLE. *Eng. & Contg.* 52, 41-2. *Ill. State Water Survey Bull.* 15, 116-20.. *Engineer* 128, 146. *Chem. Abst.* 13, 2406. Authors' conclusions: (1) Filtros plates proved the most efficient of the three types of air diffusers, as evidenced by the analytical data. They gave a sludge that settled rapidly leaving clear and stable effluents. (2) The degree of porosity of the filtros plates made no apparent difference, for the coarse and fine grades of plates gave practically the same results. (3) The wood block diffusers gave unstable effluents in the majority of samples. With these effluents the chemical results were not as satisfactory as with those from filtros plates. (4) The wooden blocks were very difficult to install, and even in the short time they were in service they showed evidence of marked deterioration. Until these defects can be remedied their installation in working-scale plants is impracticable. (5) The perforated pipes gave the least satisfactory chemical results. The majority of the effluents were unstable. (6) Clogging of the diffusers during the period covered by these experiments was not sufficient to have practical significance.

368 **Experimental study of the extraction of grease from dried activated sludge.** D. F. McFarland. *Ill. State Water Survey Bull.* 15, 108-15, (1917). *Eng. & Contg.* 52, 196-7. *Chem. Abst.* 13, 2406. Using petroleum ether as a solvent, 4.16 to 6% grease was extracted from dried, untreated sludge produced in the experimental activated sludge plant. On treating with acid, the yield of grease was 5.81 to 8.10%.

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369 **Notes on the activated sludge tests at Cleveland, O.** R. W. Pratt. *Am. Jour. Public Health* 8, 55-7. Gives results of recent experiments. A clear effluent stable for 36 hours may be produced with 0.75 cu. ft. of air per gallon in 2 hours, using 25% activated sludge. The sewage treated is high in iron and 1.75 hours more aeration is necessary to remove the iron color. A hydroturbine compresses the air which is diffused through filtros plates. Drying the sludge on sand beds required too large an area, and 7 days were required to reduce the moisture to 75%. Centrifuging has given the best results. Sludge averaged 4% ammonia, half of which is in available form. Estimated treatment cost is given for a 500,000 gallon plant.

370 **The treatment of sewage by the activated sludge process.** Anon. *Am. City* 18, 1-4; 114-9; 199-203. An installment article from a paper by Mr. T. C. Hatton read before the war convention of the Am. Pub. Health Assoc., in which the following subjects are considered. Principles of the process; character of the sewage to be treated; character of the effluent required; type of aerating and sedimentation tanks; extended studies of sedimentation; types of air diffusers and their ratio to tank surface area; period of aeration and sedimentation; volume of air required; percentage of activated sludge and volume to handle; removing sludge from sedimentation tanks and dewatering same; and special studies of dehydrating apparatus. Illustrations of the Milwaukee plant accompany the article.

371 **Activated sludge and the treatment of packinghouse wastes.** Langdon Pearse. *Am. Jour. Public Health* 8, 47-54. *Jour. Am. Leather Chem. Assoc.* 13, 145-55. *Jour. Soc. Chem. Ind.* 37, 348A. Results and conclusions of experiments carried on at the Chicago stockyards. More fully covered in references 326 and 327.

372 **Activated sludge in the treatment of sewage.** M. Young and S. E. Melling. *Sanitary Record* 61, 38, 68, 90, 122. *Surveyor* 53, 42-4. *Jour. Royal Sanit. Inst.* 39, 10-25. *Chem. Abst.* 12, 1325. *Abst. Bact.* 3, 41. General principles and bacterial actions involved are explained. Diffusers for air distribution are practicable for economic reasons. Experiments at the Davyhulme works (Manch., Eng.) show that a pulsating air supply is advantageous and minimizes the clogging of the diffusers. At Salford (Eng.) about 22% sludge by volume is used with good results, with a sewage containing considerable trade waste which at times has a very inhibitory character. Perforated pipes were used in these experiments for diffusing air, and although irregular clogging of the air jets occurred, the sludge remained active and was distributed satisfactorily in the various chambers. Results were obtained which met the dissolved O and suspended solids limits of the Royal Commis. Cost of treatment depends largely on power costs. Claims are made by the inventors of the pulsating apparatus (Ref. No. 33) that a 50% saving in power can be effected by its use. Aside from this saving two desirable effects are ensured: (1) That all the sludge is carried to the surface periodically, and (2) that the evenness of distribution is improved. The authors also point out the following as constituting decided advantages of the process:—(1) A very satisfactory effluent is obtainable. (2) Plant can be built nearer to cities, avoiding long outfall sewers. (3) Fly nuisance is avoided as activated sludge has no offensive odors. (4) The recovery of the N and its fertilizer value. Precautions to be observed in order to obtain satisfactory results, are enumerated.

373 **Sewage treatment at Manchester. (Eng.) Activated sludge research work.** ANON. *Surveyor* **53**, 4-5. *Chem. Abst.* **13**, 354. Work has been carried on in 50-gallon casks with mixed domestic sewage and an acid trade waste from chemical plants. Experimental runs indicate that the activated sludge process is successful in the presence of wastes from the manufacture of sulphate of ammonia, products from benzene and aniline, and from a dye works, but more time is required for aeration. O absorption and ammonia figures are given.

374 **The activated sludge experiments at Pasadena, Calif.** ANON. *Eng. & Contg.* 49, 36-7. *Chem. Abst.* 12, 842. Covers results obtains from Jan. 29, to Sept. 1, 1917, at the experimental plant. (Ref. No. 349.) A grit chamber, diverting box and rag-picker was installed ahead of the aerating tank. The plant was operated on both the fill and draw and continuous plans, and filtros plates set in individual cast-iron holders diffused the air. With a 4-hour aeration period and an air consumption of 1 cu. ft. per gallon of sewage, "exceedingly fine" results were obtained.

375 **Definitions of terms used in sewerage and sewage disposal practice.** ANON. *Eng. & Contg.* 49, 38-9. *Surveyor* **53**, 46-8. Amended report of the committee on sewerage and sewage disposal of the Am. Pub. Health Assoc. Definition for activated sludge same as in Ref. No. 202.

376 **Bacterial treatment of sewage.** ANON. *Engineering* 105, 40-1. *Sci. Am. Suppl.* 85, 167. *Chem. Abst.* 12, 1224. Briefly refers to the slate beds hydrolytic tanks as forerunners of the activated sludge process, and to the suggestions of DR. G. J. FOWLER, made in 1914, that sewage could be purified in tanks without the aid of filters.

377 **Fourth Annual Report of the Milwaukee Sewerage Commission.** T. C. HATTON and W. R. COPELAND. *Pamphlet* pp. 70. (Jan. 15, 1918.) Covers the following activated sludge investigations made during the year ending 1917 at the testing station. Aeration of sewage in tanks 10 and 15 ft. deep, with tabulated results; aeration periods of 2.4 to 11 hours using 0.6 to 2.8 cu. ft. of air per gallon with tabulated results and discussion of the advantages and disadvantages of various combinations from an economic point of view. Comparison of perforated pipes, wood blocks, and filtros plates as air diffusers, with the merits and demerits of each considered. But, "* * * all questions in regard to air diffusers, size of bubbles, etc., sink into insignificance when compared to the importance of furnishing clean air * * *." Sludge settlement experiments with rectangular tanks having flat bottoms, steep coned bottoms, and flat coned bottoms; and with Dorr thickeners of different depths, show that when the sludge has been well aerated the volume returned by the 15 ft. deep Dorr thickener was reduced to 20% of the raw sewage flow, and to a moisture content of less than 98%. Concentration of sludge by treatment with sulphuric acid, shows that settled sludge containing about 98% of water, can be dewatered by the acid to 91% in 2.25 hours, but that at 1 cent per lb. for 60 degree Be. acid, the cost of acid alone would be about $1.00 per million gallons of sewage, to which another dollar should be added for heating the sludge, handling acid, etc. Sludge pressing with the Worthington and Simplex plate presses, showed in both cases press cakes carrying 72 to 83% moisture. A Smith direct heat dryer reduced a press cake of 75-80% moisture to 4-10%, and a Buckeye semi-direct heat dryer reduced the moisture from 61-83% to 4-18%. Several tables of analytical and other data accompany the report.

378 **Sewage tests at Syracuse, N. Y.** NEWS ITEM. *Munic. Jour.* 44, 59. The city is awaiting the results of tests now being made by Chief Eng. G. D. HOLMES to determine whether the activated sludge or aerated filter systems is best suited for treatment of the city sewage. At the testing station, crude sewage is pumped to a grit chamber 30 ft. long, and then passed through a

bar screen with 0.75 inch spacing. Part of it then enters the activated sludge tank, the rest going to two Dortmund tanks, one with a horizontal flow filter, the other with a vertical flow aerated gravel filter. (Cf. Ref. 363.)

379 **Activated sludge in the treatment of sewage.** DISCUSSION. *Surveyor* 53, 117-9. Discussion of YOUNG and MELLING'S paper (Ref. No. 372) in which MR. T. CAINK, by letter, stated that atmospheric temperatures as low as 21°F., sewage temperature 43°F., had no appreciable effect on the purification at Worcester. (Eng.) He had, however, observed that the activated sludge process was very sensitive to sudden increases in the rate of flow through the aeration tank, the effluent being inferior; but if the same increased rate was reached gradually, it was without effect on the degree of purification. DR. E. ARDERN related some experiences at the Withington works, (Manchester, Eng.), where 400,000 gallons of sewage was being treated daily with satisfactory effluent, and with about 75% of the volume of air originally estimated on. In his opinion sludge dewatering and drying remained one of the most important problems to solve. MR. P. GAUNT, MR. W. CLIFFORD, DR. S. RIDEAL, MR. G. P. MILN, MR. W. D. SCOULLER, MR. J. A. COOMBES, and MR. G. W. LACEY brought up questions of sludge disposal and utilization, the relative merits of perforated pipes and porous tiles as air diffusers, the matter of costs, and the possibilities of converting existing plants into activated sludge plants.

380 **Sewerage and sewage disposal. The activated sludge process.** EDITORIAL. *Surveyor* 53, 71-3. Reviews the progress of the process in England and America; suggests standard units for measuring sewage, air, etc., so as to get comparable figures on volumes used; notes that porous plates have been found most satisfactory for air diffusion; and comments on the experiments on packinghouse wastes made at Fort Worth, Texas, and the proposed plant for the Chicago stockyards.

381 **Activated sludge equipment.** NEWS ITEM. *Surveyor* 53, 106. The CLIFFORD patent tank equipment (Ref. No. 275) for securing rapid settlement of activated sludge has proved a great success at the Withington works and at Stamford. JONES & ATTWOOD air diffusers have been in use over two years and showed no signs of deterioration.

382 **Sludge disposal.** ANON. *Surveyor* 53, 114-5. Abstract from the paper by K. ALLEN before the Am. Soc. Munic. Impvts. (Cf. Ref. 365.)

383 **Activated sludge treatment.** W. C. MOOR, Fort Worth, Tex. U. S. Patent 1,254,833, Jan. 29, 1918. (Assigned to ARMOUR & Co., Chicago. Application filed July 9, 1917. 6 claims.) *Off. Gaz.* 246, 1097. *Jour. Soc. Chem. Ind.* 37, 193A. *Chem. Abst.* 12, 731. Claim 5:—The method of dehydrating activated sludge which consists in heating the same to above 30 C., then subjecting the same to the action of sulphuric acid whereby coagulation takes place accompanied by the generation of gas therein and the coagulated sludge is caused to float, and then separating the coagulated floating sludge from the liquid and drying.

384 **Activated sludge treatment.** G. B. MULLOY, Chicago, Ill. U. S. Patent 1,254,836, Jan. 29, 1918. (Assigned to ARMOUR & Co., Chicago. Application filed July 9, 1917. 1 claim.) *Off. Gaz.* 246, 1097. *Jour. Soc. Chem. Ind.* 37, 193A. *Chem. Abst.* 12, 731. The improvement in the activated sludge method of treatment as applied to industrial sewage, which consists in preliminary diluting the raw sewage with effluent from previously treated sewage.

385 **Activated sludge treatment.** G. L. NOBLE, Chicago, Ill. U. S. Patent 1,254,841, Jan. 29, 1918. (Assigned to Armour & Co., Chicago. Application filed July 9, 1917. 2 claims.) *Off. Gaz.* 246, 1099. *Jour. Soc. Chem. Ind.* 37, 193A. *Chem. Abst.* 12, 731. Claim 2:—The improvement in the activated sludge method of treatment as applied to sewage, which consists in drawing off

the activated sludge from previously treated sewage, aerating such sludge for a period of about 3 hours after its withdrawal to enhance the virility of the aerobic organisms therein, and then inoculating the raw sewage with such re-vitalized sludge.

386 **Activated sludge defined.** ANON. *Eng. News-Record* 80, 205. *Can. Engr.* 34, 144. Definition as given in Ref. No. 202.

387 **Filtros air diffusing plates used in the activated sludge process of sewage treatment.** ANON. *Munic. Eng'rg.* 54, 78-9. A general description of filtros, noting the advantages of its physical properties as an air diffusion medium, and names of several localities where it is in use in activated sludge plants.

388 **Activated sludge treatment.** EDITORIAL. *Surveyor* 53, 125. Refers to YOUNG and MELLING'S paper (Ref. No. 372) and comments on the useful discussion that followed its presentation, especially that in regard to handling of the sludge.

389 **Costs of sewage screens at Milwaukee.** T. C. HATTON. *Eng. News-Record* 80, 272. In a letter to the editor MR. HATTON corrects an error in his reply to G. B. GASCOIGNE'S letter (Ref. No. 356) pertaining to the operating costs of the screens at the activated sludge plant in Milwaukee, which should be $0.46 per million gallons or a total of approximately $14,000 annually, and not half of those figures as erroneously stated.

390 **Cleveland may use fine screens for sewage.** ANON. *Eng. News-Record* 80, 382. Refers to the activated sludge process only as in Ref. No. 357.

391 **Sewage treatment and disposal.** G. B. KERSHAW. *Can. Engr.* 34, 243-5. *Surveyor* 53, 197. *Eng. & Contg.* 49, 595-7. *Chem. Abst.* 12, 1491. At the conclusion of an article on various methods of sewage purification, the author expresses the belief that the activated sludge process has a promising future, and that economical methods of dewatering the sludge and its value as a fertilizer, will determine the net cost of the process.

392 **Activated sludge disposal at Houston, Texas.** NEWS ITEM. *Oil, Paint and Drug Rep.* 93, 27. The city of Houston will erect an addition at the north side disposal plant which will be used for the manufacture of fertilizer from dried activated sludge. Estimated cost $70,000.

393 **Activated sludge process.** EDITORIAL. *Surveyor* 53, 229. Comment on a paper by T. C. HATTON, (Ref. No. 333) in which the editor notes that Mr. Hatton confirms the stand long held by the Surveyor that the quality of effluent should be suited to local needs, and controlled by varying the amount of air according to conditions of dilution.

394 **Purification of sewage by aeration in the presence of activated sludge.** R. G. TYLER. *Proc. Texas Assoc. Am. Soc. C. E.* 5, 7-13. A general description of the process, covering preliminary treatment, aeration, settlement, sludge dewatering, etc., with reference to the work done at Chicago, Cleveland, Fort Worth, Houston, Milwaukee, San Marcos and Urbana. Skilled supervision is important. Power costs must be low and at least one million g. p. d. handled to be economical for small cities. Each proposition must be worked out on its own merits. An experimental plant is under construction at Austin by the Univ. of Texas in conjunction with the city.

395 **Sewage terms recommended for adoption as a standard by a committee of the Am. Public Health Assoc.** ANON. *Munic. Jour.* 44, 223-5. An amended report which refers to the activated sludge process as in reference No. 202.

396 **Appaartus for purifying sewage.** GRIFFITHS & HARTLEY. British Patent Application No. 4,726, March 18, 1918. *Jour. Soc. Chem. Ind.* 37, 196A.

397 **Activated sludge developments.** ANON. *Can. Engr.* 34, 294. *Chem. Abst.* 12, 1674. A large settling tank at the Davyhulme works (Manchester, Eng.) is to be converted into an activated sludge tank capable of treating one million gallons of sewage per day. The Withington works, designed to treat 250,000 g. p. d. has had new features introduced which has increased its capacity to 400,000 g. p. d. The Worcester (Eng.) activated sludge plant has fulfilled the city engineer's expectations in every respect.

398 **Activated sewage sludge.** ANON. *Engineer* 125, 297-8. Considers the several methods of sludge dewatering and drying, with particular reference to the tests at Milwaukee. The commercial value of the dried sludge and methods of marketing same are also discussed.

399 **Sewage sludge as fertilizer.** ANON. *Surveyor* 53, 314. Gives value of sewage sludges on the basis of their nitrogen and phosphoric acid content, as fixed by the British Government order, and mentions a patent sludge drier using waste steam which can handle from 20 to 30 tons of sludge daily, and requires but two men to operate.

400 **Considerations leading to the recommendations for fine screens, sprinkling filters, humus tanks and sludge recovery, as the sewage disposal method for Indianapolis, Ind.** ANON. *Eng. & Contg.* 49, 368-72. From a paper by G. W. FULLER presented at a meeting of the Ind. Sanit. and Water Supply Assoc. on March 28, 1918. The activated sludge process is incidentally referred to as in references Nos. 346 and 347.

401 **Small activated sludge plant proposed at Chicago.** NEWS ITEM. *Eng. News-Record* 80, 734. Plans for an intercepting sewer and an activated sludge plant are proposed by the Sanitary District of Chicago to treat the sewage from Melrose Park, Maywood, River Forest and other villages having a total population of about 30,000. Estimated cost $750,000. (Cf. Ref. No. 598.)

402 **Purification of sewage.** W. JONES. Canadian Patent 183,586, April 16, 1918. *Chem. Abst.* 12, 1326. Air is supplied to the sewage under treatment at different points periodically, to stimulate the bacteria in the sewage. (Cf. Brit. Patent 1,141, Ref. No. 33; U. S. Pat. 1,247,541, Ref. No. 342.)

403 **Rockaway Valley sewage plans approved.** NEWS ITEM. *Eng. News-Record* 80, 839. Plans for the diversion of sewage of Rockaway Valley towns to a point below the Boonton dam of the Jersey City water supply, and treatment of the sewage there by the activated sludge process, were approved by the N. J. State Dept. of Health on April 9, 1918.

404 **Purification of sewage and other liquids.** W. JONES, Stourbridge, and JONES & ATTWOOD, L'TD., Amblecote, Eng. British Patent 132,826, April 27, 1918. *Jour. Soc. Chem. Ind.* 38, 876A. In the activated sludge process of sewage treatment, the aeration tank is constructed in longitudinal sections with the angles between the walls and floor rounded off, and also with the top of the walls made to overhang, so as to partly cover the top of the tank, the overhanging portions being curved on their under surface to the same radius as the bottom of the wall. Air diffusers are placed in the side walls near the bottom, and the combined action of the air and the rounded portions is to give a circular motion to the sewage in a transverse direction to the flow, and also to cause the air to circulate in the outer layers of the sewage. The general direction of flow is down one longitudinal section and back by another, and so on. The tank is also divided into sections by transverse walls, with the communicating openings between sections placed near the source of air supply.

By this means all the sewage is made to pass several times near the sources of air supply in its passage through the tank. Various modifications in the position of the air supply and in the wall structure are described. (Cf. U. S. Pat. 1,341,561, Ref. No. 561.)

405 **The fertilizing value of activated sludge.** G. G. NASMITH and G. P. MCKAY. *Jour. Ind. Eng. Chem.* **10**, 339-44. *Can. Engr.* 34, 377-82. *Eng. News-Record* 80, 1193. *Eng. & Contg.* 50, 31-2. *Jour. Soc. Chem. Ind.* 37, 384A. *Chem. Abst.* 12, 1229. An extended study of the subject including a report of plot experiments with activated sludge. It appears to be especially valuable to root crops. Compared with a standard barnyard manure used by farmers, the increase in yields due to activated sludge was:—with beets, 138%; radishes, 40%; late radishes, 316%; lettuce, 103.3% beans, 77.3%; tomatoes, 291%; onions, 3 varieties, 81.1, 191, and 554%. No increase was obtained with carrots. The drying and handling of the sludge is also discussed.

406 **Note on the fertilizing value of activated sludge.** PAUL RUDNICK. *Jour. Ind. Eng. Chem.* **10**, 400. *Chem. Abst.* 12, 1329. In a letter to the editor, the author claims that the experimental work of NASMITH and MCKAY (Ref. No. 405) and of BARTOW and HATFIELD (Ref. Nos. 84 and 118) does not represent conditions which will prevail in practice. The good results of the latter two are probably due to the fact that their experiments were made with sterilized soil, in which the nitrifying organisms in the activated sludge will work as well as in unsterile soil, though this is not the case with dried blood. In actual practice sterile soil is not used.

407 **Aeration of sewage and other impure liquids.** O. STOTT, Birmingham, and E. R. JONES, Stourbridge, Eng. British Patent 133,722, May 14, 1918. *Jour. Soc. Chem. Ind.* 38, 961A. In the activated sludge process of sewage purification, the treatment tank is provided with a propeller disposed longitudinally on the surface of the sewage. The propeller blades, which are of the feathering type, introduce air into the surface layer of the liquid and induce a surface current transversely to the direction of flow. Guides are placed in the tank to facilitate the continuation of the current at the sides and across the bottom of the tank. The propeller may be submerged in the sewage, in which case air is introduced into the surface by a blower or other means. (Cf. U. S. Pat. 1,343,797, Ref. No. 566.)

408 **The development of sewage treatment.** K. ALLEN. *Munic. Eng'rg.* **54**, 244-9. *Chem. Abst.* 13, 49. Development of the activated sludge process has been hindered by the war, but valuable data has been secured at Milwaukee, Urbana, and Chicago. Removal of the coarser particles by screens has reduced the volume of air required. Tank details, types of diffusers, etc., are yet to be standardized. The advantages of the activated sludge process are the small space required and the recovery of values from the sludge. Brief reference is made to methods of sludge handling.

409 **Purification of sewage by aeration. Activated sludge tanks at Lawrence Experiment Station.** EDITORIAL. *Surveyor* **53**, 457. Extracts from the 1916 Report of the Mass. Experiment Station. (Ref. No. 233.)

410 **Apparatus for pressing activated sludge.** WM. BUCKLEY, Chicago, Ill. U. S. Patent 1,271,425, July 2, 1918. (Application filed July 20, 1916. 4 claims.) *Off. Gaz.* 252, 187. *Jour. Soc. Chem. Ind.* 37, 604A. Claim 1:—In an apparatus of the class described, a container for sludge liquid, automatically operating mechanism including means adapted to receive a charge thereof from said container, and to close communication with said container thereafter, and a sludge press, said mechanism operating to force the received charge of sludge liquid into said press for the recovery of the sludge therefrom, the frequency of said operation being dependent upon the rate of filtration of the sludge through the press. (Also Brit. Pat. 130,146, Ref. No. 413.)

411 **Water-purifier.** (So titled in patent.) GEO. MOORE, Joplin, Mo. U. S. Patent 1,271,925, July 9, 1918. (Assigned to THE CHEMICAL PROCESS CO., N. Y. City. Application filed Oct. 31, 1914. 10 claims.) *Off. Gaz.* 252, 360. *Jour. Soc. Chem. Ind.* 37, 603A. *Chem. Abst.* 12, 1905. Claim 3:—In combination, a container, means for agitating sewage therein, a container communicating with the first container and adapted to allow settling of solids entering from the first container, means for discharging thickened materials from the lower portion of the second container, directly back to the first container; a third container communicating with the upper portion of the second container and adapted to receive fluid and solids in suspension therefrom, and means for separately treating products discharged from the upper and lower portions of the third container. (Cf. following abst.)

412 **Sewage treatment.** GEO. MOORE, Joplin, Mo. U. S. Patent 1,271,926, July 9, 1918. (Assigned to THE CHEMICAL PROCESS CO., N. Y. City. Application filed Oct. 31, 1914. 14 claims.) *Off. Gaz.* 252, 360. *Jour. Soc. Chem. Ind.* 37, 603A. *Chem. Abst.* 12, 1905. Claim 5:—In a process of the class described, as a continuous operation, maintaining agitation of a mass of sewage, previously coagulated sewage-solids and foreign solids, (charcoal, coal dust, peat, etc.) continuously supplying thereto original sewage, drawing off therefrom fluid portions of the mass, returning to the mass solids from the drawn off portion, and filtering the remaining drawn off portion. (Cf. previous abst.)

413 **Apparatus for pressing activated sludge.** WM. BUCKLEY, Chicago, Ill. British Patent 130,146, July 24, 1918. *Jour. Soc. Chem. Ind.* 38, 694A. (Cf. U. S. Patent 1,271,425, Ref. No. 410.)

414 **Sewage disposal at Houston, Texas.** NEWS ITEM. *Munic. Jour.* 45, 84. At the Sixth Annual Convention of the League of Texas Municipalities, held at San Antonio on June 19-20, 1918, an illustrated address on sewage disposal was delivered by E. E. SANDS, city engineer of Houston, dealing with the activated sludge plant in that city.

415 **The Worcester (Eng.) experiments with the activated sludge process.** ANON. *Eng. & Contg.* 50, 122-3. *Chem. Abst.* 13, 49. An existing tank 86 by 78 by 18 ft. deep was baffled into 36 bays, each 21 by 8 ft., of which 28 are used for aerating and 8 for settlement. Perforated pipes are used with holes 12 inches apart, over which are placed porous tiles forming the bottom of the valleys. Settling tanks have 60 degree bottoms with 6 inch air lifts. Sludge contains 96% of water. Aeration period is 6 hours, with a flow rate of one million gallons per 24 hours. 20% sludge carried. Settling period is one hour and 40 minutes. 750,000 gallons per 24 hours are actually treated. Analyses are given of the screened sewage and of the effluent.

416 **Sprinkling-filter system and auxiliaries vs. the activated sludge process.** T. C. HATTON. *Munic. County Eng'rg.* 55, 67-70. *Engineer* 124, 561. *Chem. Abst.* 12, 2643. A consideration of the relative advantages of each system. On one acre the sprinkling-filter system should handle 2.5 million gallons, the activated sludge process 10 to 15 million gallons, with respective head losses of 12 ft. as against 2 to 3 ft. Low temperatures do not materially effect the activated sludge process; it gives a clarified effluent with freedom from odor; and offers a satisfactory method of sludge disposal. The cost per million gallons for the sprinkling-filter system is estimated much higher than for the activated sludge process.

417 **Sewage engineering and sewage disposal.** J. E. WILCOX. *Munic. Eng'rg. & Sanit. Record* 62, 74, 84, 124. *Can. Engr.* 35, 224-5. *Chem. Abst.* 12, 2642. Abstract of presidential address British Assoc. of Managers of Sew. Disp. Works. The most remarkable work which has been done during the past year has been in connection with the activated sludge process, and in addition

to the installations in operation at Worcester, Stamford and Salford, a large plant has recently been installed at the Withington works, Manchester. For the past year or two most of the investigation and research work has been done in the United States, the Milwaukee experiments being especially worthy of note. The paper discusses the principal points arising in connection with the process.

418 **Means for supplying air or gas in a more or less finely divided state.** W. JONES, Stourbridge, and JONES & ATTWOOD, LT'D., Amblecote, Eng. British Patent 131,158, Aug. 17, 1918. *Jour. Soc. Chem. Ind.* 38, 790A. A layer of cement, concrete, or the like, is suppored on a perforated metal or other plate extending along the upper part of a trough, channel, or box. The top of the channel is narrower than the lower part so as to retain the porous layer. Air under pressure admitted to the channel passes through the porous cement and escapes from its surface in a finely divided state.

419 **Purification of sewage and other liquids.** W. JONES, Stourbridge, and JONES & ATTWOOD, LT'D., Amblecote, Eng. British Patent 132,581, Aug. 17, 1918. *Jour. Soc. Chem. Ind.* 38, 843A. In the activated sludge method of purifying sewage, the aerating tank is discharged during times of normal flow through an opening near the bottom. The opening is made of a size proportionate to the capacity of the tank, or it is provided with a regulator or valve, either method permitting of a continuous regulated outflow, carrying the heavier particles of sludge to a settling chamber. The top of the aerating tank is provided with a weir which comes into operation at times of abnormally increased flow of sewage, and the overflow from which joins the regulated flow passing to the settling chamber.

420 **Sewage treatment policies as influenced by war-time conditions.** G. W. FULLER. *Munic. County Eng'rg.* 55, 106-8. With respect to activated sludge, the inference is that high prices and shortage of farm labor will mean that more attention will be paid to fertilizers, and consequently stimulate investigations, not only as to activated sludge, but to sludges from other sources.

421 **Brockton postpones building its activated sludge plant.** NEWS ITEM. *Eng. News-Record* 81, 514. The State Board of Health having advised further sewage experiments, Brockton, Mass., has postponed until after the war, the building of its proposed activated sludge plant.

422 **The activated sludge process.** J. EADE. *Surveyor* 54, 131. Description of a small experimental plant at St. Albans, Eng. Aerating tank is 57 ft. 3 in. long, with a width varying from 5 ft. to 7 ft. 2 in., of 5 ft. depth, and with a capacity of 7,375 gallons. 46 diffusers having an effective area of 32 sq. ft. are located in a channel running the full length of the tank. Ratio 1 to 10. Three settlement tanks of 612, 844, and 2,125 gallons capacity, with hopper bottoms and air lifts are provided, as is also a sludge re-aerating tank of 2,194 gallons capacity, with 17 air diffusers. Air consumption averaged 12.5 cu. ft. per cu. ft. of sewage, (about 1.67 cu. ft. per U. S. gal.) treating 30,000 gallons of sewage per day, and giving a good effluent. Trade wastes from the breweries, bleaching works, gas works, a straw hat factory and a tallow factory, have not caused serious trouble with the plant.

423 **Fertilizer experiments at Toronto.** NEWS ITEM. *Surveyor* 54, 139. Fertilizer experiments with activated sludge at the Toronto sewage works produced 37 bushels of wheat per acre, as against 13 bushels when the equivalent amount of N had been added to the land in the form of dried blood.

424 **Sewage purification by the activated sludge process.** W. R. COPELAND. *Can. Engr.* 35, 302, 315-7. *Chem. Abst.* 12, 2643. Consideration in de-

tail of sewage aeration from the standpoint of the volume of air, period of contact, kind of diffusers, and depth of tanks. Air was tried in amounts ranging from 0.6 to 2.8 cu. ft. per gallon of sewage, and contact periods ranging from 2.4 to 11 hours. Filtros plates proved the best diffusers. Clean air is essential. Sedimentation is important to remove sludge. (Cf. Ref. 377).

425 **Manchester (Eng.) activated sludge plant.** NEWS ITEM. *Surveyor* 54, 166. Refers to a visit to the Withington works by members of the Assoc. of Mgrs. of Sewage Disposal works on Oct. 5, 1918, at which time DR. E. ARDERN related his recent experiences with the activated sludge process.

426 **Four methods of sewage treatment studied at New Haven testing station.** C. E. A. WINSLOW and F. W. MOHLMAN. *Munic. Jour.* 45, 280-2, 297-9, 321-2. *Eng. News-Record* 82, 32. *Chem. Abst.* 13, 626. Fine screens, Imhoff, and activated sludge, all with subsequent chlorine disinfection, and Miles' acid precipitation with sulphur dioxide were tried. The activated sludge process was studied less as an oxidizing than as a clarfying process. Trials were made with aerating periods ranging from 2.5 to 10 hours; air volume 1.1 to 2 cu. ft. per gallon; sludge volumes (very dilute sludge) 50 to 73; and sedimentation periods of 30 to 78 minutes. Satisfactory results were not obtained, partly because of faulty design of settling tank, the small size of the sludge pipes, and the lack of a re-aerating tank, but principally because of antiseptic trade wastes in the sewage, mainly copper salts from munition works.

427 **Air diffusing apparatus.** C. H. NORDELL, Milwaukee, Wisc. U. S. Patent 1,281,816, Oct. 15, 1918. (Application filed May 12, 1917. 2 claims). *Off. Gaz.* 255, 524. *Jour. Soc. Chem. Ind.* 38, 53A. Claim 1:—A liquid container having means for aerating the liquid therein, said means comprising a member having a recess provided with a concave bottom, a plurality of diffusing blocks disposed edge to edge and positioned to form an arch, said blocks being disposed in said recess in the member, the curvature of said arch conforming to the curvature of the bottom of said recess, curved spacing ribs disposed between the plurality of blocks and the bottom of said recess, and means for admitting air between the blocks and the bottom of the said recess. (Cf. U. S. Pat. 1,208,821, Ref. No. 225).

428 **Apparatus for the purification of sewage and analogous liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,282,587, Oct. 22, 1918. (Original application filed Oct. 9, 1914; divided, and this application filed Nov. 7, 1916. 8 claims). *Off. Gaz.* 255, 772. *Jour. Soc. Chem. Ind.* 38, 116A. *Chem. Abst.* 13, 151. Claim 1:—In an apparatus for purifying sewage, comprising a tank, means for introducing air or oxygen at the lower part of the tank, said tank being of a size above the air-introducing means to provide a material-receiving area above and laterially of such means, and beyond the direct influence of the air from such means. (Cf. Brit. Pat. 19,916, Ref. No. 11).

429 **Two sludge problems.** A. J. MARTIN. *Surveyor* 54, 195-6. *Chem. Abst.* 13, 354. Sewage treated by the activated sludge process requires from 20 to 70 times the amount of air necessary to furnish the O needed to combine with the organic matter. This excess is required to perform the mixing and because the air passes rapidly through the sewage. The author proposes the use of long horizontal cylindrical tanks, the contents of which are maintained in a state of rapid rotation, combined with a slow longitudinal flow. The rotation may be produced by jets of sewage or air. For the removal of a considerable part of the water or sludge, it is suggested that the sludge be allowed to settle in tall shafts, where its own weight would consolidate the material and force it out through doors at the base of the shaft. With activated sludge it might be necessary to blow air through the shaft to prevent de-aeration.

430 **All reports should be published.** EDITORIAL. *Eng. News-Record* 81, 785. Comment on the reports of the several engineers respecting the sewage disposal problems in Cleveland, O., the activated sludge process being one of the methods that has been considered.

431 **Sewage sedimentation advised for Cleveland, O.** ANON. *Eng. News-Record* 81, 806-8. From a report by H. P. EDDY in which the activated sludge process and fine screens are not recommended as a solution of the westerly district problem, because of excess cost over Imhoff tanks with disinfection, and because the activated sludge process as proposed, was to operate only during the bathing season.

432 **The recovery of grease from city sewage.** C. E. A. WINSLOW and F. W. MOHLMAN. *Munic. County Eng'rg.* 55, 173-5. *Proc. Am. Soc. Munic. Impvts.* 25, 203-22. Makes brief reference to the activated sludge process as one among a number of sewage purification processes tried at New Haven, Conn.

433 **Consolidation of sludge as a dewatering method.** ANON. *Eng. & Contg.* 50, 467. From a paper by A. J. MARTIN (Ref. No. 429) in which tall shafts are suggested. The author is not certain that this method will apply to activated sludge.

434 **Sewage mixes progressively in its passage through tanks.** H. W. CLARK. *Eng. News-Record* 81, 930-1. *Surveyor* 55, 143. *Chem. Abst.* 13, 1610. Experiments with actviated sludge and settling tanks show that the time of passage of liquid through a tank is not equal to the number of hours it would take to fill the tank as a given rate of flow. NaCl or AmCl was used to determine the time of passage. With a rate of 10.5 hours, sewage appeared at the outlet of the tank in 1 hour; 50% in 7.5 hours, while the remaining 50% lagged for 35 hours. The effluent therefore, was always a mixture of applied and held sewage. Other similar experiments are described.

435 **Purification of sewage and analogous liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,286,017, Nov. 26, 1918. (Application filed Oct. 18, 1915. 4 claims). *Off. Gaz.* 256, 766. *Jour. Soc. Chem. Ind.* 38, 116A. *Chem. Abst.* 13, 244. Claim 1:—The process of purifying sewage or the like, consisting in delivering air into the sewage to activate same, permitting such activated sewage to settle, drawing off the liquid, and utilizng the accumulated activated sludge in the subsequent treatment of raw sewage. Claim 4:—The process of purifying sewage or analogous liquid, consisting in delivering air into the liquid in the presence of bacterial sludge, collecting the air liberated from the sewage or one body of same, and delivering it into and passing it through sewage or liquid in another tank or body.

436 **Shanghai's sewage disposal and water supply problems.** ANON. *Surveyor* 54, 255. From a report on the situation by DR. G. J. FOWLER, in which it is stated that the city must look forward to the ultimate inoffensive disposition of at least 50 million gallons of sewage, and he suggests that the activated sludge process would serve both the sanitary and economic requirements.

437 **Worcester (Mass.) activated sludge experiments.** M. GAULT. *Ann. report Supt. Sewers.* (For year ending Nov. 30, 1918). Experiments at the 100,000 gallon activated sludge plant begun in July, 1917, were suspended on account of the war on Aug. 20, 1918. Report on the 13 months operation to be issued later. (Cf. Ref. 487 and 540).

438 **Apparatus for aerating sewage.** A. M. BROSIUS, Pasadena, Calif. U. S. Patent 1,286,520, Dec. 3, 1918. (Application filed Aug. 28, 1916. 3 claims).

Off. Gaz. 257, 83. *Jour. Soc. Chem. Ind.* 38, 157A. *Chem. Abst.* 13, 355. Claim 1:—In an apparatus for treating sewage, a foam chamber, means for introducing sewage into said chamber, and paddle means in said chamber for churning said sewage to form a foam. Claim 2:—In an apparatus for treating sewage, a tank, pipe means for passing air into the sewage in said tank, and a power driven mixing means for finely subdividing said air to form a foam. Claim 3:—In an apparatus for treating sewage, a tank, a down-flow pipe for passing a mixture of sewage and air to the bottom of said tank, and a power driven impeller for breaking up said mixture of sewage and air to form a foam, and for expelling said foam into said tank.

439 **Device for activating sludge.** LESTER E. REIN and JAS. W. COX, Chicago, Ill. U. S. Patent 1,286,775, Dec. 3, 1918. (Assignors to PACIFIC FLUSH TANK CO., Chicago, Ill. Application filed Oct. 6, 1916. 6 claims). *Off. Gaz.* 257, 140. *Jour. Soc. Chem. Ind.* 38, 157A. *Chem. Abst.* 13, 255. Claim 6:—In a device of the class described, a sewage tank having an inlet and an overflow outlet, a pump having an inlet member adapted to extend into said tank, a return pipe connected to the exhaust of the pump, an injector connected to the return pipe and adapted to inject air into the contents thereof, and a deflector guide arranged at the outlet of the return pipe and adapted to deflect the discharge therefrom into the body of the material in the tank.

440 **Activated sludge research in India.** ANON. *Appendix 9th Ann. Report Council Indian Inst. Science.* (Bangalore, India, 1918) *Jour. Soc. Chem. Ind.* 38, 4R. Research on activated sludge has been carried out since Nov., 1917, at a small experimental plant erected outside the applied chemistry department. Data have been obtained for the construction of the larger installation at Sakchi and also valuable information concerning the character of the sludge under different conditions, with a view of its use as a fertilizer.

441 **Sewage pollution.** DISCUSSION. *Proc. Am. Soc. Munic. Impvts.* 25, 176-93. Mr. G. B. KERSHAW (by letter) comments on the activated sludge process, stating that he would like to see an activated sludge plant run side by side with say, a percolating filter installation, both designed with the latest improvements and treating the same sewage.

442 **Water purification and sanitation.** E. ARDERN. *Ann. Reports Soc. Chem. Ind. on progress Appl. Chem.* 3, 421-7. An interesting review of the activated sludge process for the year 1918. English plants mentioned are those at Manchester, Worcester and St. Albans. American plants referred to are at Milwaukee and Houston.

443 **Report of the provincial sanitary engineer.** F. A. DALLYN. *Ann. Report Provincial Board of Health of Ontario.* 37, 58-65. *Chem. Abst.* 14, 1722. Work was undertaken with satisfactory results, to determine the fertilizer value of activated sludge.

444 **Activated sludge as a fertilizer.** W. D. HATFIELD and E. BARTOW. *Proc. Am. Soc. Munic. Impvts.* 25, 225-57. Covers historical development of sewage sludges as fertilizers; theoretical discussion of organic nitrogenous material and its decomposition products as fertilizers; expermental results with wheat, lettuce, radishes, corn, beets, onions and tomatoes, the chemical constitution of the organic nitrogenous compounds in activated sludge, which laboratory tests have shown to be principally in the form of nucleoprotein and its decomposition products; and a statement to the effect that garden experiments in 1917 proved that both wet and dry activated sludge were valuable as fertilizers, the wet sludge giving the better results. Some data on dewatering activated sludge by coagulation and by centrifugals, are also given. (Cf. Ref. Nos. 84 and 118).

445 **Notes on main drainage and its relation to river and harbor front improvements.** MORRIS KNOWLES and JOHN M. RICE. *Proc. Am. Soc. Munic. Impvts.* 25, 138-70. In the chapter on "Methods of sewage treatment," a brief general review of the activated sludge process is given.

446 **Investigations upon the purification of sewage and water at the Lawrence experiment station during the year 1918.** H. W. CLARK. *4th. Ann. Report Mass. State Dept. Health.* 117-49. A continuous flow activated sludge tank was put into operation early in the year, the average aeration period being 5.38 hours, the air supply ranging from 1.78 to 2.80 cu. ft. per gallon of sewage, diffusion being through hollow perforated brass discs. Approximately 20% of sludge was carried, the surplus being removed at intervals. The latter amounted to the equivalent of 770 lbs. of dry sludge per million gallons of sewage treated, and averaged 6.15% N, 5% fats. Investigations to learn the best volume of air for efficient aeration, and studies in regard to the effect of varying volumes of sludge are also noted. Several tables of analytical data are included.

447 **Report of the Bureau of Sanitary Engineering.** V. M. EHLERS. *Ann. Report Texas State Board of Health.* pp. 34. (1918) Refers to the activated sludge process as being received with a great deal of favor throughout the entire state, 8 cities using it in the treatment of domestic sewage, and 2 experimental plants treating packinghouse wastes. The first cost of activated sludge plants is less than that of any other type giving the same results, but several features must be first considered before adopting the process.

448 **Report on the sewage disposal problem of New Haven, Conn.** C. E. A. WINSLOW and F. W. MOHLMAN. *Pamphlet* pp. 97. (1918) The activated sludge plant is described and the results obtained from it given. (Cf. Ref. Nos. 329, 338, 354, 426 and 432).

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449 **Sewage disposal at Manchester (Eng.)** ANON. *Surveyor* 55, 17-8. *Can. Engr.* 36, 222-3. *Chem. Abst.* 13, 1889. From the annual report, Manchester Rivers Dept., for the year ending March, 1918, the following data on the activated sludge investigations are summarized. Withington works: aerating tank 100 by 20 by 6 ft. deep, of 55,000 gallons capacity, is divided into 5 channels with bottom on the ridge and furrow plan, air diffusers in the furrows. Area of net diffusion area to tank area is 1 to 10. Settlement tank 23.5 by 26.5 by 23.5 ft. deep to bottom of hopper, 27,000 gallons capacity, and equipped with CLIFFORD'S patent arrangement. (Ref. No. 274). Sludge is discharged from apex of the tank to a re-aerating tank, from which it may be returned to the aerating tank by air lifts. Plant designed to treat 250,000 gallons daily, with an average aerating period of 4 hours, and began operations in Sept., 1917. Detritus chamber and screens preceed the aeration tank. Volume of sludge carried varied from 15 to 25%. Tabular analytical data showing results of daily treatment of 250,000 gallons with a 4 hour aeration period and 1.8 cu. ft. of air; 375,000 gallons with a 3 hour aeration period and 1.2 cu. ft. of air; 500,000 gallons with a 2 hour aeration period and 0.9 cu. ft. of air are given. If nitrification is not essential, satisfactory effluents can be obtained when working at double the capacity the plant was designed for. 375,000 gallons can be handled easily. Bacterial removal was 98-99%, and the effluents were highly clarified. Sludge, on a dry basis, amounts to somewhat more than 0.5 ton per million gallons of sewage, and showed on analysis:—Loss on ignition, 75.2%, mineral matter, 24.8%. Nitrogen, 6.4%; phosphorus pentoxide, 3.8%. As removed from the settlement tank it contains 98.5% water. Davyhulme: aerating tank 25 by 16 by 9 ft. deep, operated from July, 1917, to March, 1918, on the fill and draw plan, averaging 0.5 hour to fill, 5.25 hours aeration, 1 hour, 50 min. settlement, and 0.5 hour discharging.

45,000 gallons were treated daily with an air consumption of 1 to 1.5 cu. ft. per gallon. The contemplated million gallon continuous flow plant is referred to.

450 **Purification of sewage.** HARTLEY & HARTLEY. British Patent Application 1,604, Jan. 22, 1919. *Jour. Soc. Chem. Ind.* **38**, 96A.

451 **Sewerage and sewage disposal. The activated sludge process.** EDITORIAL. *Surveyor* 55, 66-9. The possibility of draining the sludge on coarse filters protected from rain is discussed, the fertilizer value of it as disclosed in the paper of NASMITH & MCKAY is commented upon, as is the paper by MR. T. C. HATTON presented before the Am. Pub. Health Assoc. (Ref. No. 370).

452 **English activated sludge plants.** TRADE NOTE. *Surveyor* 55, 105. JONES & ATTWOOD refer to the plants of their construction at Manchester, (Davyhulme works) one million gallons per day; at Tunstall, 250,000 gallons per day; at St. Albans, at the Am. Red Cross Hospital near Sarisbury Court; at a Royal Airship Station near Worcester; and to the plants at Harpenden and Worcester.

453 **Fifth annual report of the Milwaukee Sewerage Commission.** T. C. HATTON and W. R. COPELAND. *Pamphlet* pp. 51. (Jan. 31, 1919). The reports of Ch. Eng. Hatton and Ch. Chem. Copeland for the year ending Dec. 31, 1918, gives detailed results of the operation of the chain belt fine screen at head losses of from 2 to 6.7 in., collecting 441 to 953 lbs. of screenings of 88.1 to 89.0% moisture. Analysis of these screenings show an average of 5.94% N on a dry basis. Two aerating tanks 15 ft. deep with filtros plates in the ratios of 1 to 4.4 and 1 to 6.0, treat the equivalent of 16 million gallons of sewage per acre per day, and two tanks of 10 ft. depth with the filtros plates in the same ratios, treat the equivalent of 10 million gallons per acre per day. All 4 tanks have a liquid area of 284 sq. ft. All tests showed better than 99% removal of suspended matter, 95% bacterial removal, and effluent stability of 95 to 120 hours. The standard aimed at for these factors are 95%, 90% and 72 hours. The importance of supplying clean air to the diffusers is emphasized. The lines should be of non-corrosive material so as to prevent scales of iron rust from clogging the diffusers. Dorr thickeners in the sludge settling tanks gave good service, the discharged sludge ranging from 97 to 99.5% moisture, with the overflow effluent carrying less than 5 p. p. m. of suspended solids on the average. Several tables of analytical data accompany the report.

454 **Improved fertilizer.** G. J. FOWLER and G. MUMFORD. U. S. Patent 1,294,080, Feb. 11, 1919. (Application filed June 1, 1916. 7 claims). *Off. Gaz.* 259, 289. *Chem. Abst.* 13, 1121. Claim 6:—The herein described improved fertilizer, consisting of bacterially active dry sewage sludge of granular character. (Cf. Brit. Pat. 8,397, Ref. No. 51; Dan. Pat. 22,389, Ref. No. 309; Can. Pat. 189,921, Ref. No. 467).

455 **Improvements in or relating to apparatus for use in the treatment of sewage and other effluents.** L. WHYTE, Wilmslow, and H. FOTHERGILL, Cheadle Hulme, Eng. British Patent 104,189, February 28, 1919. *Jour. Soc. Chem. Ind.* 39, 347A. The object of the invention is to provide means for thoroughly mixing together the sewage and activated sludge, and assuring that the whole of the mixture shall be brought into contact with the atmosphere. Stationary mixing devices in the form of an archimedean screw or spiral are disposed at selected points in the channels, each being of appropriate axial length and with the screw-like vanes shaped to fit closely to the bottom and side walls of the channels, which may be of rectangular or circular form, so that the whole of the mixture is effected, there being no clear flow through the channels. The mixing devices may be made of metal, earthenware, or other

material. As the mixture of sewage and sludge flows through the channels a rotary motion is imparted to it and fresh surfaces brought into contact with the atmosphere. Adapted to be used in either continuous flow or intermittant treatment tanks.

456 Analyses of sewage and sewage sludges. ANON. *Water and Water Eng'rg.* (Mar. 20, 1919). *Eng. & Contg.* 51, 465. *Chem. Abst.* 13, 1733. A typical sewage and 8 sludge analyses are given. Activated sludge shows the most N, 7.5% on dry weight.

457 Texas activated sludge plants. ANON. *Munic. Jour.* 46, 225. From a report of the bureau of sanitary engineering, Texas State Board of Health, in which the statement is made that "Texas is pecularly the home of the activated sludge process, there being 10 such plants in operation there, one of them being the first city in the world to treat the entire sewage of a city."

458 City of Sheffield sewage disposal department. J. HAWORTH. *Report of Highway and Sewerage Com.* (For 2 years ending March, 1919), pp. 10. *Sanit. Record* 63, 228-9. *Chem. Abst.* 13, 1609. *Expt. Sta. Record* 42, 188. Activated sludge experiments have been continued and developed, and two new tanks added treating 50,000 and 60,000 gallons of trade sewage per day. These tanks are 30 by 14 by 4 ft. deep, with level floors, and divided into channels about 3.25 ft. wide. Mechanical agitation is furnished by 2 vertical pistons of the Root's blower type which also circulate the sewage with a velocity of 1.5 to 2 ft. per second which is sufficient to prevent sludge settlement. 10 days were required to produce a well activated sludge, the tanks then being worked on the fill and draw plan, 3 fillings per day, continuously and satisfactorily for the past 3 months, the only air the sewage received being by contact at the surface. 20 HP. per million gallons is required. (In a private communication to the compiler, Mr. Haworth states that a plant capable of treating not less than one million gallons is being constructed, the operation of which is expected in Sept., 1920.)

459 Results of experiments with Miles acid process of sewage treatment. E. S. DORR and R. S. WESTON. *Jour. Boston Soc. C. E.* 6, (April, 1919). *Can. Engr.* 36, 455-60. *Eng. & Contg.* 51, 510-3. *Surveyor* 55, 419-21. The activated sludge process is mentioned only by way of comparison. Sludge from the acid process amounts to only one-seventh as much as from the activated sludge process and contains less moisture; 90% as against 98.5%. (Abst. of a paper on this subject by WINSLOW and MOHLMAN in *Eng. News-Record* 81, 1034-6, *Am. City* 20, 467-9. (Cf. Ref. No. 426.)

460 Operating experiences with activated sludge process for factory wastes. G. W. FULLER. *Can. Eng.* 38, 367-8. *Munic. County Eng'rg.* 57, 123-5. *Chem. Abst.* 13, 3263. Describes experiments on the wastes of a plant handling cocoanut oil, making edible oil, margarine, etc. 150,000 gallons per 24 hours with a temperature of 40 C. are treated by a plant comprising preliminary grease trap, aerating tanks, re-aerating tank, and final settling tank. Milk of lime may be added at the inlet to aerating chamber. Perforated pipes are used for air distribution. Tests showed need for organic matter, hence cow manure is added at the rate of 8 cu. ft. per 24 hours for the 150,000 gallons of waste. Air is supplied at the rate of 1.5 cu. ft. per gallon; 3 hour period of contact. 3 grains of lime per gallon are added at inlet of final sedimentation tank, producing a clear and stable effluent.

461 Reading (Eng.) and the activated sludge process. NEWS ITEM. *Surveyor* 55, 282. The town clerk of Reading has been instructed to ascertain the names of places in which activated sludge installations are in operation, either experimental or otherwise, and whether the process has proved successful.

462 **Chlorination of sewage.** ANON. *Munic. Jour. Pub. Works* 46, 266. *Can. Engr.* 36, 404. *Chem. Abst.* 13, 1733. At New Haven, Conn., the following p. p. m. of chlorine were required:—Crude sewage 7 to 8; activated sludge effluent, 3; Imhoff effluent, 6; screened sewage, 5. With the activated sludge effluent, 2 p. p. m. of chlorine reduced the total bacteria 78%. In the samples containing 3 p. p. m. of chlorine, the activated sludge process had already reduced the number of *B. Coli* 73%, and no further reduction was effected by chlorine.

463 **Activated sludge process at Worcester (Eng.).** NEWS ITEM. *Surveyor* 55, 298. Relates to financing the completion of the activated sludge plant. Large economies in the working of the system should be assured before going further.

464 **Milwaukee sewage pumping station.** T. C. HATTON. *Fire and Water Eng'rg.* 65, (April 23, 1919). A description of the pumping equipment for the new activated sludge plant.

465 **Report on the activities of the Bureau of Sanitary Engineering of the Texas State Board of Health.** R. G. UPTON. *Proc. Texas Assoc. Am. Soc. C. E.* 6, 57-8. 1919.) Over 168 sewage systems are in operation in Texas towns and all have disposal plants except a few on tide water and elsewhere. The 10 or 12 activated sludge plants are producing excellent effluents and the process is referred to as the only odorless sewage disposal method known.

466 **Apparatus for aerating sewage and other foul liquids.** R. AMES, Brighton, Eng. British Patent 143,369, April 28, 1919. *Jour. Soc. Chem. Ind.* 39, 525A. In aerating tanks, a movable device for raising the sludge to the surface, comprising a series of vertical pipes fixed in a carriage, the lower ends of the pipes being bell-mouthed, and the upper ends being provided with mushroom-shaped flanges. By means of an internal concentric pipe, and an air lift consisting of a conical box with apex below and slotted to allow air to escape upwards, or other suitable device, the sludge is raised to the surface through the bell-mouthed pipes, and then flows in a cascade over the mushroom flanges back into the tank, becoming aerated in the process.

467 **Fertilizer.** G. J. FOWLER. Canadian Patent 189,921, April 29, 1919. *Chem. Abst.* 13, 1121. Consisting of bacterially active non-colloidal sewage sludge rich in nitrogen, in a state available for plant food, made by forcing air through sewage in the presence of bacteria, thus forming an active sludge which is heated to sterilize and dry it. It is then inoculated with a portion of fresh active sludge. (Cf. Brit. Pat. 8,397, Ref. No. 51; Dan. Pat. 22,389, Ref. No. 309; U. S. Pat. 1,294,080, Ref. No. 454.)

468 **Mechanical agitation for activated sludge.** EDITORIAL. *Munic. Jour. Pub. Works* 46, 349. The experiments at Sheffield, Eng., (Ref. No. 458) apparently demonstrate that not even for oxidation purposes was applied air necessary, as sufficient O is absorbed at the surface if the sewage is kept agitated. Considered by the editor a very promising discovery.

469 **Activated sludge without compressed air.** ANON. *Munic. Jour. Pub. Works* 46, 356. *Chem. Abst.* 13, 2248. Descriptive of the experiments at Sheffield, Eng., with mechanical agitators which indicate the possible substitution of them for compressed air, surface absorption of the O being depended upon for oxidizing purposes. (Cf. Ref. No. 458.)

470 **Activated sewage process extension.** NEWS ITEM. *Surveyor* 55, 470. The Worcester (Eng.) City Council has resolved to carry out the scheme proposed by MR. T. CAINK, city engineer, for applying the activated sludge process to the whole of the remainder of the city's sewage not already so treated. The scheme proposes to treat 1.5 million gallons of dry weather flow daily at an estimated cost of 5,550 pounds.

471 **Toronto will investigate the activated sludge process.** NEWS ITEM. *Can. Engr.* 37, 46. "Officials of the City of Toronto will visit Milwaukee at an early date to investigate the activated sludge process. If satisfied with the progress made at Milwaukee the Toronto City Council will allow $50,000 for an experimental unit; which if successful will result in the construction of a large plant to handle all of Toronto's sewage."

472 **Reading (Eng.) and the activated sludge process.** ANON. *Surveyor* 56, 49. It is recommended that the sedimentation tanks be reconstructed for use in the activated sludge process, which because of local conditions, can be adopted to advantage as it will create no nuisance and produce an effluent that would meet all requirements.

473 **Separation of sludge and scum from sewage and other liquids.** S. H. ADAMS. British Patent 145,291, Aug. 1, 1919. *Jour. Soc. Chem. Ind.* 39, 581A. A sedimentation tank is provided with an apron roof, sloping longitudinally from near one wall to near the bottom of the opposite wall, and suspended on pivots. The floor of the tank slopes in the opposite direction to the roof, and at its lower side terminates in a sludge channel. Sewage enters at one end of the tank and flows over the roof towards the exit pipe at the opposite end. Solids settling out of the sewage slide down the roof into the lower portion of the tank to the sludge channel. Scum rising from the floor of the tank is directed by the under side of the roof into a scum space at the surface between the top of the roof and the side wall of the tank, from which it is removed over a weir into a scum channel. When used for activated sludge the tank is made preferably of circular form, the air inlets being so placed as to impart a revolving motion to the liquid. In this case the exit pipe is placed axially and receives the liquid through perforations along its length.

474 **Problems of sewage disposal at Shanghai, (China).** C. H. GODFREY. *Munic. Gaz.* (Shanghai) 12, 291-6. *Surveyor* 56, 225-6. *Water & Water Engr.* 21, 318-20. *Chem. Abst.* 14, 583. Extracts from a preliminary report covering the author's observations after visiting several activated sludge plants in the United States. An experimental activated sludge plant is recommended for Shanghai.

475 **Salford (Eng.) and the activated sludge process.** NEWS ITEM. *Surveyor* 56, 146. The Salford Town Council Rivers Committee recommend the adoption of the activated sludge process, successful experiments having been carried out for some time.

476 **Activated sludge plant for Chicago stockyards.** NEWS ITEM. *Eng. & Contg.* 52, 310. "The committee of the trustees of the Sanitary Dist. of Chicago voted Sept. 3, 1919, to construct an activated sludge plant for the treatment of the trade wastes from the stockyards. It also voted to request the packers to pay two-thirds of the cost of installation and operation."

477 **A sewage-treatment experiment.** ANON. *Munic. Jour. Pub. Works* 47, 199-200. *Chem. Abst.* 13, 3263. Describes an experimental plant of 50,000 gallons capacity at Mt. Vernon, N. Y., comprising a rotary driven screen, 24 mesh, with flow from the outside in, a special tank containing both aeration and sedimentation compartments, and Dorr thickeners, which treat the sewage with about one-third the usual amount of air. The plant was designed and is operated by the Dorr Co., the object being to develop a more efficient application of the activated sludge process. (Cf. Ref. Nos. 579 and 581.)

478 **Activated sludge sewage treating plant to require much power.** ANON. *Elect. Review* 75, 529-30. At the Chicago meeting of the West. Soc. Eng., MR. LANGDON PEARSE stated that electric power was proposed for the stockyards' new activated sludge plant, involving a connected load of about 12,000 H.P., and using approximately 38,500,000 kw-hr. annually. Assuming a power rate of 0.7 cent per kw-hr. the power cost for a year would be about $270,000.

479 **The utilization of sewage sludge.** J. D. WATSON. *Munic. Jour. Pub. Works* 47, 210-3; 226-7. *Can. Engr.* 37, 420-2; 427-9. Deals principally with other than activated sludge, referring to it only in a quotation from the report of a joint English Committee as follows:—"We have not specifically inquired into the results to be obtained from sewage treated by the activated process, but as a result of visits made by the Committee to the Manchester and Sheffield sewage disposal works where the activation by aeration and activation by agitation processes respectively are under investigation, it would appear that the residual sludge from such processes contained a higher percentage of nitrogen, and consequently as a fertilizer would be of greater value than sludge produced in the ordinary way. Experiments have been commenced to ascertain its fertilizing value, but further investigation is necessary to find out the best method of dewatering and drying."

480 **Utilization of sewage sludge.** EDITORIAL. *Munic. Jour. Pub. Works* 47, 219. Refers to sewage sludges in general, but concludes with the hope that the activated sludge process now operating in so many places, will furnish valuable information on the subject of their use.

481 **Bingley municipal works. Activated sludge experiments.** H. BOTTOMLEY. *Surveyor* 56, 258. Experiments have been carried out for about 15 months, successfully treating 300,000 gallons of sewage on the fill and draw plan, in a tank 8 ft. diam. by 4 ft. deep, of 1000 gallons capacity. 14 porous tiles were used as air diffusers. After the 7th filling satisfactory results were obtained with 4 hours aeration. Two fillings per day treating 750 gallons at each fill was the procedure for about 3 months. After some alterations to plant, experiments were resumed and continued for about 12 months with successful results. Aeration period varied from 2 to 9 hours. In the discussion, MR. J. P. WAKEFORD referred to the mechanical agitation experiments at the Tinsley works, Sheffield, where two tanks were being equipped to handle 200,000 gallons daily, agitation being produced by two small propellers working horizontally.

482 **Agreement reached for packingtown sewage disposal.** ANON. *Eng. World* (Nov. 1, 1919). Exerpt from a paper by LANGDON PEARSE presented at the Chicago meeting West. Eng. Soc. in Sept. Material covered by Ref. No. 533.

483 **Purification of sewage.** HARTLEY & HARTLEY. British Patent Application No. 27,205, Nov. 5, 1919. *Jour. Soc. Chem. Ind.* 38, 884A.

484 **Economic values in sewage sludge.** R. WELLS. *Munic. Jour. Pub. Works* 47, 278-80. *Eng. News-Record* 83, 948-52. *Can. Engr.* 37, 563-6. *Proc. Am. Soc. Munic. Impvts.* 26, 55-97. The following data and remarks pertaining to activated sludge are noted in this paper. Chicago Sanit. Dist. fresh activated sludge contained 5.10% ammonia; 14.70% grease. When 9 months old it contained 4.40% ammonia and 5.0% grease. Syracuse, N. Y., fresh activated sludge contained 5.06% ammonia, and 17.7% grease. In the discussion, MR. H. T. CALVERT and DR. H. MACLEAN WILSON, of Wakefield, Eng., write that activated sludge apparently contains less grease than fresh sludge, but the larger amount of N increases its value as a fertilizer. DR. F. W. MOHLMAN writes that grease extraction from activated sludge is unprofitable as the amount is greatly reduced, probably by bacterial action, a condition which does not detract from the value of activated sludge as fertilizer. When grease extraction is considered, other processes than activated sludge are advisable.

485 **The activated sludge plants at Manchester. (Eng.)** EDITORIAL. *Munic. Eng'rg. & Sanit. Record* 64, 342-3. Comments on that part of the report of the Manchester Rivers Committee for the year ending March 31, 1919, which deals with the experimental activated sludge plants installed at the Withington and Davyhulme sewage works. The Committee report that "the

satisfactory results previously obtained by the treatment of the Withington sewage by the activated sludge process have been well maintained." (Cf. Ref. No. 499.)

486 **The activated sludge system. A hospital installation.** ANON. *Surveyor* 56, 293. Illustration without detail description, of an activated sludge plant installed at the American Red Cross Hospital at Sarisbury Court, Eng., to care for the sewage of 2,000 patients and the staff.

487 **Report on the experimental treatment of sewage by the activated sludge process.** M. GAULT. *Ann. Report Supt. Sewers, City of Worcester, Mass.* For year ending Nov. 30, 1919. 473-549. An elaborate and detailed report covering structual features of the plant, operating data, and sludge dewatering experiments. Plant consisted of a bar screen, grit chamber, sewage aerating tank, sludge re-aerating tank, sedimentation tank, and sludge concentrating tank. Aerating tank was 26.25 by 14 by 10 ft. deep, divided into three channels each 4 ft. 8 in. wide, with filtros plates set in 7 rows of 4 plates each across each channel at 3 ft. 9 in. centers. A total of 84 filtros plates, and a diffuser area of 1 to 5.2. Capacity of the tank, 25,283 gallons. Sludge re-aerating tank was 12 by 5 ft. 4 in. by 10 ft. deep, divided into two channels with 4 rows of 2 filtros plates each spaced at 3 ft. clear in each row. Capacity of this tank, 4,386 gallons. Sedimentation tank was 14 ft. diam. by 9 ft. deep, with a hopper bottom tapering to 2 ft. diam. Sludge concentration tank was 3 ft. diam. by 20 ft. deep, of wood, concrete lined, with a hopper bottom sloping to 14 in. diam. Sewage treated varied from 75,000 to 125,000 gallons per day, aeration period from 4 to 6 hours, sludge re-aeration period from 3 to 6.5 hours, sedimentation period from 1.7 to 2.9 hours, air flow 1.7 to 5.0 cu. ft. per gallon of sewage, and volume of sludge carried 16 to 30%. Complete analyses of the air from the sewage and sludge re-aerating tanks are given, as well as of the sludge which averaged 1.94% solids, and contained on a dry basis, 51.12 to 71.10% organic matter, 8.37 to 17.88% iron, 3.16 to 7.35% N, and 1.86 to 9.02% fats. Numerous other tables of data accompany the report, as well as illustrations. (Cf. Ref. No. 540.)

488 **A new process of sewage purification: oxidation of sewage without a bacterial bed.** E. ROLANTS. *Rev. Hyg. et Police Sanit.* 41, 459-78. *Exp. Sta. Record* 42, 188. *Chem. Abst.* 14, 2671. A review of the work on sewage purification by the activated sludge process.

489 **The activated sludge process at Tunstall. (Eng.)** ANON. *Surveyor* 56, 366. Illustration without detailed description of the converted aerating tanks which are treating 300,000 gallons of sewage per day by the activated sludge process.

490 **Treatment of sewage sludge.** G. MUMFORD. British Patent Application 30,579, Dec. 6, 1919. *Jour. Soc. Chem. Ind.* 38, 968A.

491 **Results of 1918 operations of the testing station of the Milwaukee Sewerage Commission.** ANON. *Eng. & Contg.* 52, 669. *Chem. Abst.* 14, 1175. It is concluded from the report of MR. W. R. COPELAND, Chief Chemist, that endless belt plate screen with slots 1-8 by 2 in., with a 2 in. loss of head, will handle 3 million gallons of sewage per 24 hours upon 27 sq. ft. of wetted area, and remove 150 lbs. of dry solids per million gallons. Aerating tanks 15 ft. deep treated the equivalent of 16.5 million gallons of sewage per acre per day. Tanks 10 and 15 ft. deep were tried, all equipped with filtros plates as air diffusers. Sludge and rust filled the holes in perforated pipes so quickly that it was necessary to empty tanks and clean the pipes after 2 days run. Air must be thoroughly cleaned. Dorr thickeners proved successful in concentrating the sludge in the settling tanks. Tables of analytical data are given.

492 **Present status of the sewage disposal problem.** G. G. NASMITH. *Contract Record* 33, 1137-40. *Can. Engr.* 37, 519-22. *Surveyor* 57, 19-21. Chem. Abst. 14, 1173. General problems are discussed, chiefly the nuisance

of sludge treatment. Numerous features of the activated sludge process are referred to, the author stating that the principles underlying this process and trickling filters are identical, and that the complete solution of the sewage disposal problem will eventually come through a combination of one of these processes with sludge digestion. Efforts to recover soluble nitrogenous values in sludge are made difficult by their collodial nature, and it may be better to dissolve and oxidize as much organic material as possible, turn out a smaller quantity of stable residue, and make no attempt at conservation.

493 **Activated sludge plants in Texas.** ANON. *Eng. News-Record* 83, 920. Besides the two large plants at Houston, smaller plants have been put in at Coleman, Gainesville, San Angelo, San Marcos and Quanah. (Also at Sherman, Paris, and Fort Worth. J. E. P.)

494 **Sewage purification problems.** EDITORIAL. *Surveyor* 56, 398. Comment on the paper of MR. A. J. MARTIN (Ref. No. 495) in which approval is given the suggestion that a central testing station be established, in order that all new methods of sewage disposal may be judged on their merits.

495 **Sewage purification problems.** A. J. MARTIN. *Surveyor* 56, 401-2; 419. *Eng. & Contg.* 53, 364-5. *Chem. Abst.* 14, 2389. The activated sludge process is referred to as the most promising novelty for the purification of sewage which we have had, and that a way will be found to very materially reduce the power now required so that the process will become valuable. Sludge dewatering and its use as a fertilizer is discussed.

496 **Progress in sludge dewatering tests.** EDITORIAL. *Eng. News-Record* 83, 973. The work at Houston, Texas, is referred to (Ref. No. 497) but is considered as still in the experimental stage. If sludge dewatering can be done practically and economically, it may assure the success of the activated sludge process which produces a sludge of high N content.

497 **Notes on the activated sludge plants at Houston, Texas.** ANON. *Eng. News-Record* 83, 1003-4. *Chem. Abst.* 14, 440. City engineer J. C. MCVEA and principal assistant G. L. FUGATE supply the following data. The north side plant, started in May, 1917, rated at 10 million gallons per day, is now treating 5.5 million gallons daily. Plant cost $254,671. South side plant, started in August, 1918, rated at 5 million gallons per day, cost $115,085. The filtros plates when first installed were held by cast-iron holders, the rust from which clogged the plates so they were removed and set in concrete. Washing with hot HCl restored their porosity to nearly the original capacity. Sludge presses in operation—two Simplex presses of 120 plates each—indicate that 18,000 lbs. of sludge of 98.25% moisture, can be reduced to 80% moisture in 8 hours. Addition of 0.65 gallon of 66 Be. sulphuric acid per 1000 gallons of sludge aids dewatering and increases the N content of the sludge from 5.47 to 6.93%. Cost of treatment by the activated sludge process is about $12 per million gallons, and it is expected that the revenue from the sludge will pay the cost of dewatering and drying same, as well as interest and depreciation on the $85,000 invested. 0.5 ton of sludge per million gallons of sewage, and a profit of $4 to $10 per ton of sludge is estimated. 10% moisture basis. Stability of effluent is obtained as long as 1 p. p. m. of nitrate is present in the treated sewage. The free ammonia results are an index of the condition of the effluent, ranging from 22 p. p. m. in the crude sewage to 2 p. p. m. in the effluent. The latter is remarkably clear. Removal of suspended matter is about 95%.

498 **$6,000,000 sewage scheme recommended for the western part of York Township, Ontario, Canada.** *Can. Engr.* 37, 559-60. Abstract from the report of engineers FRANK BARBER and R. O. WYNNE-ROBERTS. The method of treatment will be either by means of tanks and filters or by the activated sludge process.

499 **Development of the activated sludge process at Manchester. (Eng.)** ANON. *Surveyor* 56, 417-8. *Can. Engr.* 38, 245-7. *Chem. Abst.* 14, 1400. Excerpts from the annual report of the Manchester Rivers Dept. for the year ending March 31, 1919. At the Withington works 172,000 gallons per day were handled, with air varying from 0.8 to 1.7 cu. ft. per gallon of sewage, and sludge varying from 15 to 30%. Nitrification varied from 0.10 to 0.65 grain per gallon, the nitrite and nitrate N being calculated as ammonia. The tanks are 6 ft. deep, and the diffusers therein have been used for 2 years with a replacement of 6 out of 300. In wet weather 0.8 cu. ft. of air maintains a good effluent. The plant works well on varying rates. 0.5 ton of dry sludge is produced per million gallons: as discharged it contains 98.8% moisture. Centrifugal dewatering has not been encouraging. At Davyhulme the fill and draw plant has handled 45,000 gallons per day. A large plant is under construction, comprising a grit chamber, aerating tanks, sludge reaction channel, and settling tanks of circular type cleaned by a scraper, and also a hopper bottom type. This plant will handle 1 million gallons per day with 6 hours aeration, and with 2 to 4 hours re-aeration. Diffusers are one-eighteenth tank area.

500 **Milwaukee sewage-testing station: experimental data.** ANON. *Eng. News-Record* 83, 1063. *Surveyor* 57, 244. *Chem. Abst.* 14, 439. Data from the 1918 reports of Ch. Eng. T. C. HATTON and Ch. Chem. W. R. COPELAND. Sewage was screened through Hamburg type screens with 1-8 in. wide slots, which protects the aeration tanks from coarse debris and enable the equivalent of 16.5 millions gallons of sewage per acre per day to be treated, as against 7 million gallons without screening. Suspended matter removed 99%; bacteria removed 95%; stability over 100% on their standard. The air at the plant is sooty and clogged the filtros plates, hence it was filtered through a layer of 12-oz. duck and then through canton flannel, which improved it. Galvanized iron pipes are preferred for air distribution, as black iron pipes soon rust and the rust clogs the air passages.

501 **The Sanitary District of Chicago. Stockyards (sewage) treatment plant.** COMMITTEE REPORT. *Pamphlet* pp. 32. (Dec. 1919.) Reports of the committee on engineering, the chief engineer, and the attorneys, respecting the treatment of sewage from the stockyards district, and the relations between the Sanit. Dist., the packers, and others, concerning the construction, maintenance, operation, and income from a treatment plant suitable for the purpose. The activated sludge process is favored.

502 **Water and sewage purification.** A. C. HOUSTON. *Ann. Reports Soc. Chem. Ind. on the Progress of Appl. Chem.* 4, 482-5. The review of the activated sludge process for the year 1919, is confined almost exclusively to the work at the Sheffield (Eng.) plant.

503 **Brooklyn, N. Y., sewage treatments experiments.** G. T. HAMMOND. *Trans. Am. Soc. Munic. Impvts.* 26, 98-198. *Eng. & Contg.* 53, 39. *Fire and Water Eng'rg.* 66, 1278-82. Refers in passing to the activated sludge and aeration experiments, but an account of this work is reserved for a separate paper.

504 **Bureau of Sanitary Engineering. Municipal Sanitation.** C. W. GODDARD and V. M. EHLERS. *Texas State Board of Health, publication No. 3.* pp. 18. (1919.) The activated sludge process should be considered by the smaller towns only when very cheap power is available and objections are made to other methods of sewage treatment. For larger cities where a revenue can be obtained from the sludge, the method may prove to be the most economical one. More efficient handling of the sludge is desirable. Comparative initial costs of activated sludge plants are approximated at about one-half that of a "Scresetfildis" plant. (Screens, settling, filtration, disinfection.)

505 **English activated sludge plants.** ACTIVATED SLUDGE, L'TD. *Trade Circular* (undated). Illustrates and refers to the following plants:—Manchester; Davyhulme works; the fill and draw installation of 1914, and the later continuous flow plant; Withington works; plant treating 250,000 g. p. d. with 4 hours aeration and 82% purification, or 375,000 g. p. d. with 3 hours aeration and 81% purification. The Worcester works, in operation continuously since 1916, purifying 750,000 g. p. d. The plant at Stamford treating 100,00 g. p. d. of strong sewage containing much abattoir refuse, with an average purification of 90% by the O absorption test, and of 86% by the albuminoid ammonia test. A plant at the National Filling Factory at Aintree, operating since 1916 on the wastes of 2000 workers. A plant for the Admiralty Airship Station at Moreton; population 400. The experimental plant at Harpenden for H. M. Bd. of Agr., for producing activated sludge for fertilizer tests. A plant for the Am. Red Cross Hospital near Southampton; population 2000. A plant for a Gov. cartridge factory at Blackpole, completed in 1917 and treating the sewage from 4000 workers. A plant at Tunstall, treating 300,000 g. p. d.

506 **Sewage disposal.** *Book.* L. P. KINNICUTT, C. E. A. WINSLOW and R. W. PRATT. Second Edition, 1919. Chapter XII, pp. 381-405, deals with the activated sludge process from an historical, experimental and practical point of view, discusses the results obtained at several places, and gives a list of references to the subject.

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507 **Activated sludge process of sewage purification.** E. ARDERN. *Munic. Eng'rg. & Sanit. Record* 65, 11-2, 26. *Surveyor* 57, 8-9. *Chem. Abst.* 14, 583. A review of the experiments in England as presented in an address at the meeting of the Assoc. of Mgrs. of Sewage Disp. Works. At the Withington works (Manchester) there is a tank of 20,000 gallons capacity, capable of treating 45,000 gallons of sewage daily, also a 250,000 gallon plant with aerating chamber 100 ft. long, divided by baffles into 5 channels each 4 ft. wide. This plant could handle 350,000 g. p. d. Effluents were satisfactory, purification quite good and air consumption less than 1 cu. ft. per gallon. 300 diffusers have been in use for two years and only 8 removed for cleaning. Air pressure is 3.1 lbs. Fertilizer experiments with activated sludge at the Harpenden plant are referred to, and mention made of the activated sludge plants at Tunstall, Bury, for the army, and some institutions. MR. J. KERSHAW, P. LAMB, J. BOULTON, W. H. MAKEPEACE and A. J. MARTIN participated in the discussion which included such matters as elasticity of plant, effect of gas liquors on the purification, mechanical agitation, sludge treatment and costs of air compression.

508 **British Sanitary Engineering developments in 1919.** EDITORIAL. *Engineer* 129, 10-2. *Eng. & Contg.* 53, 357-9. *Chem. Abst.* 14, 2524. Concerning the activated sludge process, it is noted that despite the fact that it has had adverse conditions to contend with during practically the whole of its existance, it has made a wonderful amount of headway. Refers to the new experimental million gallon plant at the Davyhulme works (Manchester) and a small plant at Harpenden. Reading has decided to treat the whole of its sewage by the activated sludge process. The results of producing fertilizer material from activated sludge are also noted.

509 **Bacterial flora of sewage purified by the activated sludge process.** P. COURMONT and A. ROCHAIX. *Compt. rend.* 170, 75-8. *Jour. Soc. Chem. Ind.* 39, 171A. *Chem. Abst.* 14, 1400. The bacterial flora of samples of sewage before and after treatment by the activated sludge process were studied. Aeration was carried out in a small laboratory apparatus. The total bacterial reduction was considerable; in one sample the number of organisms

was reduced from 202 million per cc. to 67,000. The bacterial species found in the purified sewage were few in number and all aerobic, chromogenic species predominating. No *B coli* were found.

510 **Record forms for activated sludge plants, Houston, Texas.** G. L. FUGATE. *Eng. News-Record* 84, 75. *Chem. Abst.* 14, 790. Daily report sheets as used at Houston are reproduced.

511 **Proposed activated sludge plant at Burnley (Eng.)** NEWS ITEM. *Surveyor* 57, 27. A committee after visiting the Sheffield activated sludge plant, suggest to the Council that the process be tried at Burnley.

512 **Sixth Annual Report of the Milwaukee Sewerage Commission.** T. C. HATTON. *Pamphlet* pp. 49, with inserts. (Jan. 15, 1920). The report of Ch. Eng. Hatton for the year ending Dec. 31, 1919, states that the Commission unanimously and formally adopted the activated sludge process. The work at the testing station may be summarized as follows:—Grit chamber; little information was obtained owing to weather and sewage conditions. Screens: chain belt screens with 1-8 in. and with 3-32 in. slots, sewage with 274 to 350 p. p. m. suspended solids, head on screens 2 to 4 in., passed 128,435 to 246,000 gallons per sq. ft. of wet screen area, from which 472 to 1,017 lbs. of screenings of 85 to 87.2% moisture were collected per million gallons of sewage. Aerating tanks: there was a slight difference in favor of the 15 ft. depth of tank, not taking into consideration the extra cost of compressing air for a 15 ft. dept of liquor over that for a 10 ft. depth. Indications pointed to easily treating 12 millions g. p. d. per acre in 10 ft. deep tanks, and 20 million g. p. d. per acre in 15 ft. deep tanks. 155,000 gallons of sludge of 97.4% moisture were returned to the aerating tanks p. m. g. of sewage treated. Excess sludge was 12,100 gallons of 97.5% moisture p. m. g. of sewage treated. Ratio of diffusion plates of 1 to 4.4 was more favorable than 1 to 6. Contact period ranged from 4 to 6 hours. Volume of air per gallon of sewage was 1.25 cu. ft. though less could be used but for the agitating effect desired. Experiments showed that owing to the fluctuation in the character of the sewage, and to prevent the light floculent sludge from rising to the surface, that a 15 ft. deep sedimentation tank was necessary, and that with this depth of tank, 1,600 to 2,000 gallons of mixed liquor per sq. ft. of tank area, could be satisfactorily clarified. Sludge re-areation tests do not appear to justify the additional tankage and air required for the purpose. After one year's run there was no evidence that the filtros plates had in any way been reduced in porosity or stability. Air was filtered through 10 oz. duck, then through canton flannel, and washed by the hydro-turbo blower. Sludge pressing and drying investigations are still in progress. Thus far, filter press experiments indicate about 3 lbs. of sludge cake of 80% moisture per sq. ft. of filter cloth in 4.5 hours, from a sludge containing initially 97.5% moisture. The report of the Ch. Chem. for the year is issued as a separate document.

513 **Treatment and disposal of sewage.** H. B. HOMMON, J. K. HOSKINS, H. W. STREETER, R. E. TARBETT and H. H. WAGENHALS. *U. S. Public Health Reports* 35, 101-31. *Chem. Abst.* 14, 1721. The description of the activated sludge process is very brief, covering in short paragraphs; theory, outline of plant, process, advantages and disadvantages, and general. Under the latter head reference is made to the proposed or existing plants at Milwaukee, Chicago and Houston, Texas. A bibliography of 30 references concludes the article.

514 **Sewerage and sewage disposal. The activated sludge process.** EDITORIAL. *Surveyor* 57, 75-7. Reviewing the activated sludge work for the year 1919, reference is made to the plant at Manchester (Withington works) where 172,000 gallons of sewage has been treated daily on an average, throughout the year, with an effluent of uniformly high purity, and with 1

cu. ft. of air per gallon, except when a high degree of nitrification was required. Sludge averaged 0.5 ton of dry matter p. m. g. sewage. Reference is also made to the mechanical agitation experiments conducted by MR. J. HAWORTH at Sheffield, Eng., and to methods of sludge treatment.

515 **Studies of methods for the treatment and disposal of sewage.** L. C. FRANK and C. P. RHYNUS. *U. S. Pub. Health Bull.* 101. *Expt. Sta. Record* 43, 189. Incidentally refers to the activated sludge method as among those studied at one time.

516 **The activated sludge process.** TRADE NOTE. *Surveyor* 57, 119. "—in July last (1919) a limited company (Activated Sludge Lt'd.) was formed to acquire the full control of all patents held by Messrs. JONES & ATTWOOD, Limited, of Stourbridge, and others—relating to this process." AMES-CROSTA apparatus. "For several years past the company (Ames-Crosta Sanitary Engineering Co., Lt'd.) has devoted close attention to the treatment of sewage by activated sludge—and it is hoped that an installation on a large scale of machinery of a distinctly novel character,—will be ready for inspection in a very short time."

517 **Sewage disposal in small cities and towns.** M. F. STEIN. *Munic. County Eng'rg.* 58, 71-5. Refers to the activated sludge process as offering a substitute for the Imhoff tank-trickling filter plant, but is more compact and probably produces an effluent of greater purity. It is largely on an experimental basis at present. The difficulties of the process are those of operating under the limitations of practical conditions as against experimental, and the disposal of the sludge.

518 **Modern sewage disposal plant at San Angelo ,Texas.** ANON. *Am. City* 22, 147-8. An activated sludge plant located less than 1,000 ft. from the main street of the city, adjoining a public park, and operating only in the day time. Two old septic tanks 110 by 20 by 8 ft. deep, and 60 by 20 by 8 ft. deep, were utilized, half of the larger tank being converted into an aerating chamber, in which the air is distributed through perforated pipes. The other half receives the raw sewage where it is detained for about 3 hours for plain sedimentation. The smaller tank receives the night flow of sewage from which it is injected to the aeration tank during the following day. A sludge settling tank 20 by 18 by 25 ft. deep adjoins the aerating tank. Plant has a capacity of 400,000 g. p. d. but is treating only 225,000 g. p. d. at present. Effluent is clear and sparkling with a slight musty but not offensive odor, and is discharged into a nearby river. Stability tests with methylene blue have shown it to be well within the requirements of the law.

519 **The origin of the activated sludge process.** EDITORIAL. *Surveyor* 57, 199. *Eng. & Contg.* 53, 726. *Chem. Abst.* 14, 2524. A consideration of the claim of the Lawrence, Mass., and Manchester, Eng. workers, in which the editor concludes that "—it is not too much to say that the credit for the development of the laboratory observations and deductions, and their translation into practice, is due entirely to the Manchester workers."

520 **The activated sludge process.** ANON. *Surveyor* 57, 201-2. Refers to the report of the Lawrence, Mass., experiment station for the year 1917, (Ref. No. 362) quoting therefrom on the activated sludge experiments recorded, and taking exception to the "remarkable American claim" that it is "essentially a Lawrence process."

521 **Sewage disposal methods of London, Eng.** ANON. *Surveyor* 57, 205. *Eng. & Contg.* 53, 762. *Chem. Abst.* 14, 2524. Statement that the laboratory activated sludge experiments after many failures and adjustments gave sufficiently successful results to justify investigation on a practical scale. These experiments, undertaken prior to the war and suspended on account of it, are to be revived.

522 **Glasgow and the acivated sludge process.** NEWS ITEM. *Surveyor* 57, 208 "An exhaustive investigation has strongly convinced a deputation of the Glasgow Corporation sewage committee of the value of the activated sludge process." The advantages of the process over all other methods, especially as to the values recovered from the sludge, will result in a recommendation for an activated sludge plant at Shieldhall.

523 **The origin of the activated sludge process.** EDITORIAL. *Surveyor* 57, 216. Refers to the opinions of the American experts, (Ref. No. 524) and notes that they agree with those of the editor.

524 **The origin of the activated sludge process.** ANON. *Surveyor* 57, 222. Quotations from the second edition of "Sewage Disposal," pages 282-3, by Kinnicutt, Winslow and Pratt, from which it may be noted that DR. G. J. FOWLER "'—to whom is due the actual discovery of the activated sludge process—'" admitted that "'—the illuminating idea which originated the work was due to the visit he had paid while in the United States to the Mecca of sewage purification—namely, the experiment station at Lawrence in the State of Massachusetts.'" "'Nevertheless, American engineers should reciprocate Dr. Fowler's graceful acknowledgement by recognizing that none of the investigations on this side of the water had really brought sewage aeration to a state of practical usefulness. It was the Manchester studies, and particularly the discovery of the effectiveness of previously aerated or 'activated' sludge in promoting oxidisation, which really gave us this important method of sewage purification.'"

525 **Experience with the activated sludge process at Manchester (Eng.)** ANON. *Eng. & Contg.* 53, 280-2. Data from the last annual report of the Manchester Rivers Dept. on the fill and draw plant at the Davyhulme works, and description of the large continuous flow plant there under construction, also on the plant at the Withington works. (Cf. Ref. No. 499).

526 **Fine screen specifications for the activated sludge plant at Milwaukee.** T. C. HATTON. *Eng. News-Record* 84, 511. *Chem. Abst.* 14, 1400. The specifications call for screen plates not less than 3-16 in. thick with slots 3-32 in. minimum width, by 2 to 2.5 in. long. These screens are for a plant to treat 130 million g. p. d. normal flow, and 190 million g. p. d. storm flow.

527 **The activated sludge process of sewage purification—large-scale operation.** E. ARDERN. *Jour. Soc. Chem. Ind.* 39, 60-4T. *Surveyor* 58, 427-8. *Chem. Abst.* 14, 1865. A large-scale continuous flow plant, to replace the experimental plant was installed for the treatment of Withington sewage late in 1917. A description of the installation and a general account of the results are given.

528 **Purification of sewage with activated sludge.** R. CAMBIER. *Compt. rend.* 170, 681-4. *Jour. Soc. Chem. Ind.* 39, 347A. *Chem. Abst.* 14, 2388. *Chem. & Met. Eng'rg.* 23, 440. During the first few minutes of contact of raw sewage with activated sludge, there is a considerable reduction in ammonia without a corresponding increase in nitrate N, which shows a marked increase only after one hour. The phenomenon is less appreciable if old sludge is used, and in this case, if aeration is prolonged excessively, there results a decomposition of the sludge with production of nitrate. The effects of aerating ammonia-free water in the presence of washed activated sludge for a period of several days, was to reduce its volume from 500 to 50 cc., and to produce in the liquid 360 mg. nitrogen trioxide. The sludge was found to be entirely inactivated. In the presence of activated sludge nitrification is most rapid between 20 and 25 C. Aeration for 2 hours are required as compared with 15 hours at 0 C. and 4 hours at 5 C. Above 30 C. nitrate is produced in very slight amounts, and at 37 C. (optimum temperature for nitrification in pure culture) only a trace of nitrate is formed and there is

no clarification of the sewage. If a mixture of activated sludge and sewage after nitrification is decanted after 3 hours, the liquid in the interstices of the sludge is found to be considerably denitrified. The nitrifying capacity of the sludge, however, is not effected thereby. Both the ammonia and colliodal matter of the sewage are for the most part absorbed by the sludge at the moment of contact.

529 **Development of sewage purification.** S. H. ADAMS. *Can. Engr.* 38, 314-5. In a letter to the editor, reference is first made to certain technical journals raising the question as to who invented the so-called activated sludge process, followed by a brief review of the progressive development of sewage purification for the past 30 or 40 years, noting the "air-activation" work of DR. CLARK at Lawrence and DR. FOWLER at Manchester, and the "mechanical-activation" work of MR. J. HAWORTH at Sheffield, the concluding paragraph containing the statement that "—these changes from land irrigation, chemical precipitation, contact beds and sprinkling filters to activated and mechanically agitated sludge, are but simple evolutionary stages in the solution of a difficult problem—."

530 **Formation of activated sludge.** F. DIENERT. *Compt. rend.* 170, 762-3. *Jour. Soc. Chem. Ind.* 39, 347A. *Chem. Abst.* 14, 2229. In the preparation of activated sludge, air is bubbled for a certain time through sewage, which is allowed to settle, the water drawn off, fresh sewage added, air again bubbled through, this being repeated until during a period of bubbling for 5 consecutive hours, 20 mg. of ammoniacal N per liter of sewage is converted into nitrous or nitric N. Experiments with various samples of sewage and water showed that the time required to produce activated sludge depends upon the water employed, its temperature, and the quantity of air used. Before being activated the sludge of sewage has little if any action upon the water in which it was formed. Analysis of water made 5 days before activation of the sludge gave 3.0 mg. per liter of N as nitrates before aeration, and 3.7 mg. after 4 hours aeration; the figures for ammoniacal N were 14.9 and 14.0 respectively. The day the sludge became active the figures were 2.4 and 12.0 mg. nitrate N before and after 4 hours aeration, and the ammoniacal N 16.2 and 1.0 mg. respectively. Analysis of the sludge gave as follows: after an aeratoin period of 58 days, but 5 days before it became active, the total nitrate N was 36.4 mg. per gram of dry sludge, and the ammoniacal N 1.3 mg. On the day the sludge became active, after an aeration period of 63 days, the figures were 31.5 and 1.5 respectively. The condition of activation is reached abruptly. In experiments with water from the tanks of the Pasteur Inst., it was proved that a nitrous fermentation took place after the period of activation, nitrate N only appearing after several weeks. During an activation period of 11 days, each time after 24 hours aeration, all the ammonia introduced (20 mg.) was recovered, but on the 12th day all the ammonia was transformed into nitrites.

531 **Activated sludge process considered at London, Eng.** ANON. *Eng. News-Record* 84, 616. Authority to visit some of the English activated sludge plants has been requested by a committee, apparently to study the process with a view of its adoption in London. The volume of sewage discharged from the two London outfalls is 348,000,000 g. p. d., and about 2,000,000 tons of sludge are dumped into the sea annually.

532 **Canada's first successful activated sludge sewage system at Brampton, Ont.** G. G. REID. *Contract Record* 34, 292-7. *Chem. Abst.* 14, 2042. In 1908 Brampton built a pair of reinforced concrete tanks, each about 13 ft. wide by 100 ft. long, with covers. In 1918-19 the old tanks were converted into aeration chambers and a two-chamber settling tank was added, 30 by 16 by 22 ft. deep with two pockets at the bottom. Filtros air diffusing plates are used. The plant is operated 15 hours per day, aerating at night. (Cf. Ref. No. 548).

533 **Treating the waste of Packingtown, Chicago.** LANGDON PEARSE. *Jour. West. Soc. Eng'rs.* 25, 365-73. *Public Works* 49, 251-3. *Chem. Abst.* 14, 3489. A brief review of the packinghouse industrial waste problem in Chicago. The packers have agreed to pay 60% of the cost. The results of the testing station are briefly reviewed. The activated sludge process proved most practicable, offering a possible recovery of fertilizer material and grease. The plans recommended included intersepting sewers, fine screens, aeration for 8 hours using 4 cu. ft. of air per gallon of sewage, settling, handling the sludge with acid, filter pressing and rotary driers. A stability of 80 to 90% in summer and 30 to 60% in winter, was obtained in the tests.

534 **Origin of the activated sludge process.** H. W. CLARK. *Surveyor* 57, 308. In a letter to the editor Dr. Clark quotes from published articles by DR. FOWLER, DR. H. MACLEAN WILSON, ARDERN & LOCKETT, and from the reports of the Lawrence Expt. Sta., also from correspondence of Dr. Fowler, in support of the author's contention that the process originated at Lawrence. "There is no intention on our part to belittle or depreciate the further development of this process by English workers, but in its essentials it is a Lawrence process; and if, in 1912, we had not shown the work then being carried on to Dr. Fowler, the process would not have been taken up in England for further study. The gallon bottles and carboys in which this process was being carried on by us in 1912, and which were shown to him, were operated in all essential details exactly as activated sludge tanks are today, and producing equally good results, although we had not at that time given the process the very attractive name afterwards attached to it by the English workers."

535 **Action of activated sludges on the ammonia of sewage and of ordinary water.** F. DIENERT and GIRAULT. *Comptes rend.* 170, 899-901. *Jour. Soc. Chem. Ind.* 39, 382-3A. *Chem. Abst.* 14, 2670. The activated sludge prepared as previously described (Ref. No. 530) causes the disappearance of ammoniacal N from sewage and from ordinary water in an almost identical manner, the ammoniacal N content of the water having been made equal to that of the sewage. The experiments were made by means of allonges in a water bath at 25° C., in each of which was placed 450 c. c. of activated sludge containing about 12 grams of dry matter at 120° C., and 1500 c. c. of sewage or ordinary water, the ammonia content of each being known. The same amount of air was made to bubble through the mixture until the ammonia had passed out, when the time required for its disappearance was noted and the nitrates and nitrites then determined. On each day the liquid in the two allonges was decanted and replaced by other samples of the same nature containing known amounts of ammonia, and the determinations repeated. This was continued for 9 months, the average figures for each month being given. As the sludge gets older the ratio of ammonia oxidized to time of disappearance, at first diminishes, then increases. Nitrous N only appears after the sludge has been used for several months.

536 **Filtros plates successfully cleaned.** G. L. FUGATE. *Eng. News-Record* 84, 754. *Chem. Abst.* 14, 1865. The removal of iron rust from filtros plates in the activated sludge plant at Houston, Tex., was accomplished successfully by immersing them in HCl (strength not given) at 98° C.

537 **The origin of the activated sludge process.** W. CLIFFORD. *Surveyor* 57, 328. A letter to the editor referring to the letter of H. W. CLARK (Ref. No. 534) in which the author contends that "Sufficient surface of slate or other material upon which abundant growths may occur—is not an essential condition of the activated sludge process."

538 **The fertilizing value of sewage sludges.** W. E. BRENCHLEY and E. H. RICHARDS. *Chem. Age.* (Lond.) 2, 404. *Jour. Soc. Chem. Ind.* 39, 145R, 177-82T. *Chem Abst.* 14, 3743. Results of experiments (pot) with activated and slate-

bed sludges are given. With 1 and 6 units of activated sludge, barley showed 65 and 92% increase in the weight of the crops over that of the control sample. After barley had been cropped, mustard was sown in the soil left in the pots, the 6-unit pot showing an increase of 940% over that of the control sample, from which the authors conclude that activated sludge may be of considerable utility because of the high residual value.

539 **Action of the bacteria of sewage purified by the activated sludge process on albuminoid material, urea, and nitrates.** P. COURMONT and A. ROCHAIX. *Comptes rend.* 170, 967-70. *Jour. Soc. Chem. Ind.* 39, 423A. *Chem. Abst.* 14, 2671. The proteolytic properties of the 7 species of bacteria found in the effluent from sewage purified by the activated sludge process are either absent or much reduced, according to the reactions of these species towards coagulated serum, gelatin, egg albumin, milk casein, and the production of indole. Five of the 7 gave indole following action on peptone, but not upon the other albuminoid material studied. *B. subtilis* attacks each of the albuminoid substances yielding albumoses, peptones, leucine and tyrosine. It secretes a rennin but not casease, and it slowly attacks urea. Three of the 7 are active in the fermentation of urea and three entirely without action. Two of the species were without action upon nitrates in bouillon or peptone; the other 5 were direct denitrifying bacteria, as shown by their action on potassium nitrate, some of which were very active.

540 **Activated sludge experiments at Worcester, Mass.** RAY S. LANPHEAR. *Eng. News-Record* 84, 819-23. *Chem. Abst.* 14, 1865. The experimental activated sludge plant consisted of a bar screen, grit chamber, sewage aeration tank, sludge aeration tank, sludge concentrating tank, and a shallow tank for measuring excess sludge previous to disposal. The bar screen, 0.5″ openings, removed 11.4 cu. ft. screenings p. m. g. of sewage treated. At least 2 cu. ft. of air per gallon and 4 hours aeration was required for weak sewage and 3 cu. ft. of air and 6 hours aeration for strong sewage. Filtros air diffusers were used. Albuminoid ammonia must be below 2 p. p. m. if a stability of 75% is desired. The effluent was clear but contained considerable suspended matter. Dissolved oxygen was low in the effluent and nitrification was absent. On account of the presence of industrial wastes and the strength of the Worcester sewage, the process is considered unsatisfactory. The sludge analyzed:—total N, 4.06%, available N, 1.39%; total phosphorus pentoxide 2.26%; citrate soluble 1.76%.

541 **Sewage treatment plans for the Chicago Sanitary District.** ANON. *Eng. News-Record* 84, 873. *Chem. Abst.* 14, 1865. The plans comprise the following program:—Construction of an activated sludge plant at Maywood to abate the nuisance in the Des Plaines River; negotiations for a large activated sludge plant for the stockyards district costing $9.5 million; also negotiations for treatment plants at Corn Products Co. and chrome tannery of Greiss-Pfleger Co., and the treatment of the sewage from the Calumet region.

542 **By-products from sewage sludge.** R. S. WESTON. *Am. Jour. Public Health* 10, 405-7. *Chem. Abst.* 14, 2041. Interest in fat and fertilizer recovery from sludge is renewed because of the shortage of fats and fertilizers during the war, and the discovery of the activated sludge and Miles processes for sewage treatment. Both of these processes are briefly described.

543 **St. Louis Meeting Am. Chem. Soc. Water, Sewage and Sanitation division.** ANON. *Jour Ind. Eng. Chem.* 12, 419. Activated sludge and other methods proposed for the treatment of sewage, especially those applicable to the wastes from industrial plants, was discussed at this meeting.

544 **Modern methods of sewage disposal.** E. S. CHASE. *Am. City* 22, 485-9. A popular article on the subject, referring to the activated sludge process as one with a low first cost, requiring careful operation, comparatively small

area, but somewhat more elaborate machinery than the older processes. It produces a clear, sparkling, colorless effluent and the bacterial removal is high. The sludge, if handled rapidly, is inoffensive and has a value as fertilizer material.

545 **Action of activated sewage sludges.** F. DIENERT, F. WANDENBULKE and M. LAUNEY. *Comptes rend.* **170**, 1089-92. *Jour. Chem. Ind.* **39**, 424A. *Chem. Abst.* **14**, 2670-1. Experiments were made to determine the influence of varying amounts of activated sludge upon the rate of nitrification of Seine water containing increasing quantities of ammonia. To 1 liter samples of this water there was added 400, 200, 100, and 50 c. c. of activated sludge, corresponding to 12, 6, 3, 1.5 grams of dry matter at 100° C. Air was bubbled through at the rate of about 50 liters per hour. Points determined were the amount of ammonia driven off and of nitric and nitrous N formed. Tests were made with the following amounts of ammonia per liter: 20 mg. for 1 hour; 40 mg. for 1 hour; 40 mg. for 2 hours; 60 mg. for 2 hours; and 60 mg. for 3 hours. By thus varying the amounts of activated sludge and ammonia it was found that the ratio of ammonia destroyed to the dry weight of the sludge introduced, diminishes as the amount of sludge used increases. The results of this process of sewage purification were checked by bacterial counts upon different samples. It rapidly gives an effluent free from ammonia and non-putrescible, but on account of the great difference in the composition of the various waters, the reduction in the number of bacteria was very variable.

546 **The nitrogen in sewage.** G. M'GOWAN. *Surveyor* 57, 405-7. *Eng. & Contg.* 53, 736-8. *Chem. Abst.* **14**, 3735. Referring to the activated sludge process, the author notes that the conservation in this sludge of the more readily assimilable N of the sewage colloids and solids—N which hitherto has been in great part lost—should prove a marked asset in its favor. Pot cultures and field plot experiments made with it are mentioned.

547 **Action of the bacteria of the flora of sewage purified by the activated sludge process on carbohydrates.** P. COURMONT and A. ROCHAIX. *Comptes rend.* **170**, 1134-5. *Jour. Soc. Chem. Ind.* **39**, 465A. *Chem. Abst.* **14**, 3440. The bacteria of the flora of sewage purified by the activated sludge process exert a marked fermenting action on carbohydrates. Varies with the species.

548 **Reconstructed septic tanks serve as activated sludge plant.** ANON. *Eng. & Contg.* 53, 543. Because of the nuisance, the town of Brampton, Ont., Can., remodeled a septic tank 100 ft. long by carrying down one longitudinal wall about 6 ft. to a horizontal bottom about 3 ft. wide, a 1 to 1 slope being carried to the opposite wall. The tank was also divided into 6 sections by cross walls. Filtros plates in the horizontal bottom diffused the air. A settling tank 30 by 16 by 22 ft. deep was built with 2 chambers which slope to hoppers 4 by 4 ft. Surplus sludge is dried on outside beds. Plant operates 15 hours per day with one attendant and has received the approval of the Provincial Board of Health. (Cf. Ref. No. 532.)

549 **The work of the water and sewage laboratory of the Mass. State Board of Health.** ANON. *Eng. & Contg.* 53, 552-3. At the present time the principal sewage studies at the station are in regard to the activated sludge process, which is stated to have had its inception at Lawrence in 1912, in the purification of sewage by aeration and growths.

550 **Results of activated sludge experiments at Milwaukee.** ANON. *Eng. & Contg.* 53, 554. *Chem. Abst.* **14**, 2388. Abstract of the Sixth Annual Report of the Milwaukee Sewerage Commission. (Cf. Ref. No. 512.)

551 **Separation of suspended matters from sewage.** ACTIVATED SLUDGE LT'D. and COOMBS. *Jour. Soc. Chem. Ind.* **39**, 434A. British patent application No. 13,202, of May 13, 1920.

552 **Sewage purification plants.** ACTIVATED SLUDGE LT'D. and COOMBS. *Jour. Soc. Chem. Ind.* 39, 434A. British patent application No. 13,203, of May 13, 1920.

553 **The nitrogen in sewage.** DISCUSSION. *Surveyor* 57, 426-7. In discussion of DR. M'GOWAN'S paper (Ref. No. 546), A. P. I. COTTERELL referred to the mechanical agitation experiments at Sheffield, and to the activated sludge fertilizer tests at Harpenden. A. J. MARTIN suggested means for aeratnig sewage at less cost and J. FIELDHOUSE related a case where T. N. T. and chemical wastes had injuriously interfered with the activated sludge process.

554 **Activated sludge moves forward.** EDITORIAL. *Eng. News-Record* 84, 989. Comment on T. C. HATTON'S paper (Ref. No. 555), considering some features from the practical point of view that apply especially to Milwaukee. The activated sludge process is very promising and it is hoped that it may eventually take a leading place among the several methods of sewage treatment.

555 **Activated sludge plant for the city of Milwaukee.** T. C. HATTON. *Eng. News-Record* 84, 990-6. *Public Works* 48, 536-8. *Surveyor* 58, 21-3, 48-9. *Chem. Abst.* 14, 2229. Plans are for treating 85 million g.p.d. in 1930 and 130 million g.p.d. in 1950. The plant will comprise bar screens, grit chambers, revolving slotted fine screens 3-32″, and activated sludge treatment. The bar screens will be spaced 3 11-16″ apart. A velocity in the grit chambers of from 0.64 to 1.0 second feet is provided. The aeration tanks (2) are 340 ft. long, 22 ft. wide and 15 ft. effective depth, with filtros plates set at right angles to the direction of flow and 4.5 ft. between centers. The sedimentation tanks are 72 ft. square and are provided with Dorr thickeners. The treated sewage will be discharged into Lake Michigan at 14 ft. depth. Air required is 1.5 cu. ft. per gallon of sewage. Tanks 15 ft. deep are more effective than those 10 ft. deep. Sulphuric acid—4.5 c. c. per gallon of sludge—assists in dehydrating it. The sludge and screenings are to be pressed and then dried in revolving driers. Coarse screenings are estimated at 40 lbs. p. m. g.; grit 2.3 cu. ft.; fine screenings at 618 lbs. with 87.2% moisture, and excess sludge at 12,100 gallons p.m.g. of sewage treated. Contact in the aeration tanks is based on a 6 hour period. The cost of the plant is estimated at $5,000,000.

556 **Activated sludge experiments at Champaign-Urbana, Ill.** NEWS ITEM. *Eng. News-Record* 84, 1034. It is proposed to install at first a 100,000 g.p.d. activated sludge plant complete in every particular. Experiments will be directed particularly to the reduction of the amount of air used and to drying the sludge. The old plant at Champaign will be utilized in part. DR. EDWARD BARTOW, Chief Ill. State Water Survey, will direct the work.

557 **The activated sludge process: Reading's £148,000 scheme.** ANON. *Surveyor* 57, 440. The activated sludge process is recommended by M. TAYLOR as particularly suitable for Reading, the sedimentation tank scheme held up by the war, being abandoned.

558 **The progress of sewage disposal.** A. J. MARTIN. *Surveyor* 57, 446. A popular lecture on the subject, in which the activated sludge process is briefly described. This new process has been very favorably received, its chief drawback being the great bulk of the resultant sludge and the difficulty of drying it.

559 **"Forced Aeration" sewage treatment.** ANON. *Public Works* 48, 446. *Can. Engr.* 38, 522. As the result of a prize offered by *Munic. Eng'rg. & Sanit. Record* (London) for a new name for the activated sludge process, no less than 20 were submitted from which "Forced Aeration" was chosen.

560 **New Name for activated sludge.** EDITORIAL. *Public Works* 48, 447. The editor considers "forced aeration" less descriptive of the activated sludge process than the name it would replace, and questions its adoption.

561 **Purification of sewage and other liquids.** W. JONES, Stourbridge, Eng. U. S. Patent 1,341,561, May 25, 1920. (Application filed Aug. 8, 1919. 4 claims.) *Off. Gaz.* 274, 755. *Jour. Soc. Chem. Ind.* 39, 526A. Claim 1:—In a purification system, a tank divided into a plurality of communicating open chambers, and an air supply for each chamber, the walls of the chamber being formed to direct the flow of the liquid under the pressure of the air supply in a circulatory path within the chambers. (Cf. Brit. Pat. 132,826, Ref. No. 404.)

562 **Tunstall activated sludge plant.** NEWS ITEM. *Surveyor* 57, 469. At a meeting of the Midland District of the Assoc. of Mgrs. of Sewage Disposal Works, held at Tunstall, the activated sludge plant was inspected, the process being explained in detail by the sewage engineer, W. H. MAKEPEACE.

563 **Purification of sewage by activated sludge.** R. CAMBIER. *Comptes rend.* 170, 1417-9. *Jour. Soc. Chem. Ind.* 39, 525A. A very slight trace of chloroform in the air bubbled through the sewage during treatment by the activated sludge process is sufficient to inhibit the formation of nitrates. Similarly, if air saturated with chloroform is bubbled through the sewage for one hour, and then pure air for four hours to remove the chloroform, on the introduction of the sludge and the subsequent bubbling of air, the ammonia disappears, but no nitrates are formed. Further, attempts to isolate nitrifying organisms from activated sludges were not successful. These results are opposed to the view that nitrification takes place during the purification of sewage by the activated sludge process.

564 **Sewage effluents for disposal with and without dilution.** ANON. *Eng. News-Record* 84, 1161-2. *Chem. Abst.* 14, 2960. From a report on sewage works operation submitted to the Sanit. Eng. Sec., Am. Pub. Health Assoc. in Oct., 1919. The normal characteristics of activated sludge effluents as produced experimentally are as follows:—"(1) Low total suspended solid matter. (2) A practical absence of settleable suspended matter. (3) Presence of oxidized nitrogen as nitrites or nitrates in amounts equivalent to or better than in sprinkling filter effluents. (4) A low oxygen demand. (5) A high reduction in total bacteria content." The importance of skilled supervision for practical activated sludge plants is emphasized.

565 **Separation and settlement of solid matters from sewage and other liquids.** WM. CLIFFORD, Oxley, Wolverhampton, Eng. U. S. Patent 1,343,764 June 15, 1920. (Application filed March 27, 1918. 2 claims. Assigned to JONES & ATTWOOD, L'TD., Amblecote, Eng.) *Off Gaz.* 275, 539. *Chem. Abst.* 14, 2388. Claim 1:—A settling tank, an inflow pipe, a guard about the delivery end of said pipe and comprising a cylindrical casing of uniform diameter throughout with open ends above and below said inflow pipe, and a vessel closed at the bottom and open at the top arranged centrally within and wholly above the lower end of the guard, the inflow pipe directing the material into the open end of said vessel. (Cf. Brit. Pat. 117,472, Ref. 275.)

566 **Aeration of sewage and other impure liquids.** OSWALD STOTT, Birmingham, Eng., and ERNEST R. JONES, Stourbridge, Eng. U. S. Patent 1,343,797, June 15, 1920. (Application filed June 21, 1919. 6 claims.) *Off. Gaz.* 275, 546.. *Jour. Soc. Chem. Ind.* 39, 557A. *Chem. Abst.* 14, 2388. Claim 1:—In a process of purifying sewage and other impure liquids in which the purification is effected by bacterial sludge and air, artificially circulating the sewage or liquid, and at the same time ruffling or agitating the surface, so as to cause the introduction of air into the liquid by said ruffling or agitation. (Cf. Brit. Pat. 133,722, Ref. No. 407.)

567 **Activated sludge plant at California State Prison.** ANON. *Eng. News-Record* 84, 1260. The activated sludge plant at the Folsom State Prison has served a population of about 1500 for two years with excellent results,

though operated by convict labor that is very unreliable. Air diffusion through perforated pipes has given almost no trouble. The activated sludge plant proposed for Hermosa Beach has never been constructed, hence the Folsom plant is the only activated sludge plant in California.

568 **The treatment of sewage—activated sludge system, Folly Point, Sydney.** ANON. *Commonwealth Eng.* 7, 330-2. *Chem. Abst.* 14, 2833. Because increased volume of sewage made plant additions necessary, the activated sludge system was adopted instead of installing additional septic tanks. Both septic tanks and the activated sludge system are in use at the present time.

569 **Stream pollution in Illinois.** LANGDON PEARSE. *Jour. Am. Waterworks Assoc.* 7, 549-52. *Chem. Abst.* 14, 2833. Refers to the proposed activated sludge plant for treating packinghouse wastes in Chicago, the experiments on tannery and corn-products wastes, and to the ultimate treatment of all sewage in the entire Sanitary District of Chicago.

570 **Purification of sewage by activated sludge.** R. CAMBIER. *Comptes rend.* 171, 57-60. *Chem. Age* (Lond.) 3, 76. *Jour. Soc. Chem. Ind.* 39, 556-7A. The ferrous sulphide normally present, or artificially introduced, into sludges, appears to be an important factor in the purifying and nitrifying action of these sludges on sewage. It is frequently noticed that when such sludges lose their activity a reddish color due to ferric hydroxide is apparent. All the causes which tend to destroy the ferrous sulphide, or modify its physical state, equally tend to destroy the activity of the sludge. It was found that sludges which had become practically inactive could be re-activated by the addition of either ferrous sulphide or of equimolecular proportions of solutions of ferrous sulphate and ammonium sulphide.

571 **London County Council's large-scale experimental works.** ANON. *Surveyor* 58, 23. *Chem. Abst.* 14, 3735. At the southern outfall works, lime-water tanks at present out of use, are to be equipped for activated sludge experiments capable of treating 250,000 g. p. d. One tank is to be equipped on the principle adopted at Manchester and Worcester,—air agitation—and one on the plan adopted at Sheffield,—mechanical agitation.

572 **A sewage farming possibility.** EDITORIAL. *Eng. News-Record* 85, 145-6. Refers to possible use of Los Angeles, Calif., sewage for land irrigation, and suggests that the activated sludge process as a preliminary treatment might be worth looking into. The Pasadena activated sludge experiments are referred to as a near-by source of information.

573 **Activated sludge exhibit.** NEWS ITEM. *Surveyor* 58, 64. *Chem. Age* (Lond.) 3, 133. At the Health exhibition of the Royal Sanitary Institute Congress held at Birmingham (Eng.) in July, 1920, an exhibit of the activated sludge process attracted much attention.

574 **Some points to observe in the design of sewerage systems and disposal works.** THEO. HORTON. *Munic. & County Eng.rg.* 59, 58-9. While conceding the activated sludge process to be practical, it seems to have some inherent features which are difficult to control, and it is therefore not being very generally adopted.

575 **Proposed sewerage and water supply scheme for Port Colborne, Ont., Canada.** ANON. *Can. Engr.* 39, 269. For this town of 4,000 population R. O. WYNNE-ROBERTS recommends the activated sludge process of sewage treatment.

576 **The design of Cleveland's sewage treatment works.** G. B. GASCOIGNE. *Eng. News-Record* 85, 344-9. *Chem. Abst.* 14, 3488. A consideration of the different plants proposed and reference to the activated sludge investigations made.

577 **Sewerage and water developments at Decatur, Ill.** ANON. *Eng. News-Record* 85, 457-8. *Chem. Abst.* 14, 3487. During 1917 small scale tests were made with the activated sludge process on mixed industrial and domestic sewage, and in 1919 the activated sludge process was tried on crude starch waste alone. The process was found applicable in the first case but not in the latter. The normal city sewage consists of a mixture of about 4,250,000 gallons of domestic and 1,250,000 gallons of industrial sewage daily. Decision has not been made as to the type of treatment plant.

578 **Sewage disposal.** C. H. GODFREY. *Munic. Gaz.* (Shanghai), 13, 317-8. *Surveyor* 58, 292. A report of the author's visit to India and Burmah. When treating sewage by the activated sludge process it is important to break up the solids or remove as much of them as possible by screens. The mechanical agitations experiments at the Sheffield activated sludge plant are referred to.

579 **Relation of chemical engineering to sewage and trade waste treatment.** R. H. EAGLES. *Chem. & Met. Eng'rg.* 23, 438-40. The activated sludge process is briefly described, with special reference to the various means of air diffusion. Attention is directed to the common use of air far in excess of theoretical requirements. The use of the Dorr thickener for sludge concentration and problems in connection with its dewatering and drying are also discussed. The Dorr company's activated sludge plant at Mt. Vernon, N. Y., is mentioned.

580 **A novel laboratory for industrial research.** ANON. *Chem. & Met. Eng'rg.* 23, 496-8. Refers to the Westport mill of the Dorr Co. Their modification of the activated sludge process is very briefly described. After passing a revolving screen the sewage is aerated in a specially designed thickener which affects distribution and circulation of the air bubbles in one chamber, and causes sedimentation in another chamber. The indications are that aeration may thus be accomplished in less time and at less cost than by other means, as less air is used. Research work on biological sludge treatment is in progress.

581 **Activated sludge experiments at Mt. Vernon, N. Y.** R. H. EAGLES. *Eng. News-Record* 85, 490-2. *Chem. Abst.* 14, 3488. 45,000 gallons of rather strong domestic sewage are treated daily, first passing a 0.75" bar screen. The plant proper consists of a "Dorrco" rotary screen and two combination aeration-sedimentation tanks in series, each 12 ft. in diameter by 11 ft. deep, with a total capacity of 17,600 gallons. Aeration occurs in the lower compartment where the liquid depth is 6.5 ft., air being diffused through filtros plates. Approximately 75% of the air used is introduced into the first unit and 25% in the second. Sedimentation takes place in the upper compartment. Purification is effected by 0.6 cu. ft. of air per gallon of sewage, with an aerating period of 8 to 10 hours. Effluent is clear, colorless, contains less than 20 p. p. m. of suspended solids (initially 245 p. p. m.), up to 1 p. p. m. nitrate and nitrite N, and is stable at least 4 days by the methylene blue test. 90% of the bacteria is removed and the O consumption reduced 79.6% (initially 154 p. p. m.) The dry sludge has 7 to 9% N as ammonia. Some tabulated data are given.

582 **Sewage disposal research work.** NEWS ITEM. *Surveyor* 58, 188. The Ministry of Health have investigated the results of the activated sludge process at various locations and is continuing the work. The use of sewage sludge as fertilizer has also been investigated in co-operation with the Ministry of Agriculture and Fisheries.

583 **Reading (Eng.) sewage disposal.** NEWS ITEM. *Surveyor* 58, 221. *Eng. News-Record* 85, 833. Authority to borrow the necessary funds for the building of an activated sludge plant capable of treating the entire sewage of the city has been given. The plans have been prepared by G. M. TAYLOR.

584 **Disposal of waste.** F. W. PARSONS. *Saturday Eve. Post.* 193, 36-8. A popular article on sewage disposal practice, with particular reference to the Milwaukee activated sludge plant, illustrating the 2 million g. p. d. plant built in 1917.

585 **Peterboro favors Imhoff tanks, Municipal Board orders activated sludge.** NEWS ITEM. *Can. Engr.* 39, 410. Because the Ontario Board of Health refuses to permit the discharge of Imhoff tank effluent into a river, the Municipal Board says an activated sludge plant must be installed, notwithstanding a favorable report on the Imhoff tank process by the city council.

586 **The activated sludge process.** EDITORIAL. *Surveyor* 58, 225. *Can. Engr.* 39, 627-8. Refers to the approval of the Reading (Eng.) activated sludge scheme by the Ministry of Health as an official endorsement of the process, and briefly summarizes the progress which the process has made since 1914. It is concluded that the activated sludge process has now definitely emerged from the experimental stage.

587 **North Shore Sanitary District's sewage disposal problem.** W. J. ALLEN. *Fire & Water Eng'rg.* 68, (Oct. 13, 1920). Aeration strongly advised, with thickening machines suggested as a method of separating the sludge from the liquid.

588 **Activated sludge process at Sydney, Australia.** J. W. SMAIL. *Ann. Report Met. Board of Water Supply and Sewage.* (1919-20.) *Jour. Inst. Munic. & County Engrs.* ? *Eng. News-Record* 85, 780. Six activated sludge tanks displace septic tanks, three of which are in operation treating 900,000 g. p. d. on the fill and draw plan, 12 hour cycle. 7 hours aeration, 2 hours settling, 1 hour decanting, 2 hours sludge re-aeration. Centrifugal sludge dewatering experiments are in progress.

589 **Am. Soc. Munic. Impvts. St. Louis Meeting, 1920.** ANON. *Eng. News-Record* 85, 815. *Public Works* 49, 385-7, 461-3. The advances in the activated sludge process were brought out by the papers of LANGDON PEARSE and PROF. E. BARTOW, and in the discussion following. A description of the Argo, Ill. plant, of the Chicago stockyards plant, and a brief history of the activated sludge work of the Chicago Sanit. Dist. was given by Mr. Pearse. Prof. Bartow's paper on the present status of the activated sludge process reviewed recent work and described the new experimental plant at Urbana, Ill. T. C. HATTON reported the total cost of operating the Milwaukee plant as $35 p. m. g., with credit for sludge values of $18, or a net cost of $17 p. m. g. of sewage treated. J. C. MCVEA stated that the cost of operating the Houston activated sludge plant was $14 p. m. g., exclusive of overhead and sludge treatment. Sludge handling methods were discussed. The process as yet is applicable only in special cases.

590 **Ter Meer sludge dewaterer at Milwaukee.** ANON. *Eng. News-Record* 85, 889. This is a centrifugal machine of German make under trial at the activated sludge plant. Preliminary tests gave a 4 inch cake and thus far the machine is giving a satisfactory product. Because the sludge varies greatly between winter and summer as to colloid content, filter press operation seems uncertain.

591 **Activated sludge in England.** EDITORIAL. *Eng. News-Record* 85, 1018. Comment on the approval of the activated sludge plant for Reading (Eng.) by the Ministry of Health. "* * * the adoption of the activated sludge process for all the sewage of so large a British town (nearly 100,000 pop.) is something that may well be noted by American engineers."

592 **The disposal of trade wastes.** R. S. WESTON. *Public Works* 49, 504-6. A general description of the nature and origin of various trade wastes

and their effects in sewage, referring to the activated sludge process only in connection with its failure to successfully purify the sewage at New Haven, because of the poisonous nature of the copper salts present.

593 **Activated sludge.** EDITORIAL. *Surveyor* 58, 374. Comment on the report of W. H. MAKEPEACE on the Tunstall activated sludge plant. (Ref. No. 595.) The process is shown to be entirely satisfactory from every point of view, including both construction and maintenance costs. The suggested requirements for a complete scheme of activated sludge treatment should be useful to other engineers.

594 **Sewage disposal at Manchester, (Eng.)** ANON. *Surveyor* 58, 375. Extracts from the annual report of the Rivers Dept. for the year ending March 31, 1920. The fill and draw activated sludge plant at Davyhulme has operated throughout the year, receiving 3 or 4 fillings per day with an aerating period of 4 to 5 hours. The large continuous flow plant has been completed but is not yet in service because of delays in obtaining operating equipment. Research during the year has been confined almost exclusively to activated sludge investigations, including experiments on the acceleration of sludge settlement by means of tank design, acid and various electrolytes; dewatering the sludge by filter pressing and centrifuges, the latter being the most promising; tests relating to aerating tank design, from which it appears that the length of travel through the tank is not as important as first thought, provided thorough admixture of sludge and sewage is effected, and a prolonged investigation of the N content of the sludge in relation to that of the sewage treated, the results of which should be available for publication shortly.

595 **Activated sludge experiments at Tunstall.** ANON. *Surveyor* 58, 380. Extracts from the report of W. H. MAKEPEACE, sewage engineer, which is summarized as follows:—"* * * it marks a distinct advance in the methods of treating sewage and possesses many possibilities over the other types. It is reliable when once established. It is not likely to be interfered with by trade wastes of our district. It is considerably less costly to construct. It certainly would be less costly to maintain than our existing plants. It causes no aerial nuisance under the worst conditions. It is controlled by a much smaller though more skilled staff. It can often be applied without a pumping scheme. The resultant sludge possesses higher fertilizing value than the sludge from existing plants. The sludge is not offensive. Portions of our existing plants can be readily adapted to the fill and draw method. It complies easily with all the requirements of the Royal Com. recommendations."

596 **Large activated sludge installation at Reading, Eng.** ANON. *Eng. News-Record* 85, 1125. Plant designed to ultimately handle 4,200,000 g. p. d. and will be the largest activated sludge plant in England. Will comprise screens, detritus chambers, 4 aeration tanks with a total capacity of 2,100,000 gallons, 2 settling tanks, total capacity 540,000 gallons, sludge storage tanks of 180,000 gallons, and a re-aeration tank of 312,000 gallons. (All U. S. gallons.)

597 **Houston activated sludge plant results.** ANON. *Eng. News-Record*, 85, 1128. As given by J. C. MCVEA, city engineer, at the St. Louis meeting, Am. Soc. Munic. Impvts. One plant is handling a little more than 6 million g. p. d., the other about 1 million. Total air used is 1.44 cu. ft. per gal. of sewage treated, divided 0.94 cu. ft. in the aerating tanks, 0.44 cu. ft. in the re-aerating channels and 0.06 cu. ft. for the air lifts. Average aerating period is 2.25 hours. Re-aerating sludge 4 hours 40 min. Suspended solids are reduced 96-98%, O consumed 50 to 84%, relative stability about 98%. The effluent is clear and unoffensive.

598 **The Des Plaines River activated sludge plant.** LANGDON PEARSE. *Eng. News-Record* 85, 1134-8. This plant is under construction at Riverside,

Ill., by the Sanit. Dist. of Chicago. It is designed to care for the sewage from a population of over 30,000 and with a wide flexibility for practical and experimental purposes. Coarse bar screens are followed by a two-compartment grit chamber, each compartment being 47 by 3.5 by 3 ft., and this by a Riench-Wurl screen 14 ft. in diameter. Four aerating tanks are provided, all 126 ft. long inside. One, 21 ft. wide by 15 ft. deep, and one, 30 ft. 4 in. wide by 10 ft. deep, both baffled once longitudinally, will be used as straight flow tanks. One, 10 ft. deep, divided by baffles into 4 longitudinal channels each 7 ft. 7 in. wide, will treat sludge re-aerated during its return, and another of the same dimensions and design will be run with sludge re-aerated and settled before re-use. All aerating tanks have ridge and furrow bottoms with filtros plates in concrete containers in the furrows. Ratio, 1 to 5.7, to 1 to 5.9. Settling tanks with hopper bottoms and others with Dorr thickeners are provided, with air lifts for handling the sludge. For sludge concentration or storage 6 tanks 15 ft. square by 11.5 ft. deep are provided. Filter presses, a centrifuge of the Ter Meer type and a direct-indirect dryer are to be used for sludge handling. Cloth screens and a hydroturbine blower will supply clean air.

599 Tunstall activated sludge experiments. W. H. MAKEPEACE. *Surveyor* 58, 397-8. The plant comprises a detritus tank 21 by 9 by 5.5 ft. deep of 6,700 gallons capacity, aerating tanks (converted filter plant) 75 by 42 ft. 9 in. with semi-circular ends and average depth of 7 ft. 9 in., of 156,875 gallons capacity, divided into 10 chambers; sedimentation tank 25 ft. diam. by 13 ft. 10.5 in. deep of 42,500 gallons capacity. Aerating tank floor is on the ridge and furrow plan with porous tile diffusers at the bottom of the furrows. 300,000 g. p. d. are treated on the continuous flow plan. The plant was subjected to abuses likely to arise in practice and stood all the tests satisfactorily. "* * * it is a vast improvement and advance on any known method, not only for its thoroughness, but for its more hygenic methods during treatment."

600 Notes on sludge disposal. J. E. FARMER. *Surveyor* 58, 412. With respect to activated sludge, it is suggested that the liquid sludge be pumped directly onto the land to be fertilized. Laboratory experiments show that the odor of ordinary sewage sludge is changed to an earthy smell if treated by aeration as in the activated sludge process, and that there is no loss of N. In the discussion, (p. 430) C. H. BALL stated that a "drying tank" to deal with 5,000 tons of activated sludge per annum was being installed at Manchester.

601 Assoc. of Managers of sewage disposal works. General meeting in London. ANON. *Surveyor* 58, 413-4. Excerpts from the presidential address of A. J. MARTIN, in which reference is made to the Worcester and London activated sludge experiments, to the proposed plant at Milwaukee, and that of the Chicago Sanit. Dist. in the stockyards. Also to DR. G. MCGOWAN'S paper on the nitrogen in sewage. "The outstanding feature of the year has undoubtedly been the continued progress of activated sludge."

602 Activated sludge experiments in England. ANON. *Munic. Eng. and Sanit. Record* 66, *? Public Works* 49, 567-9. From a report of W. H. MAKEPEACE on the Tunstall sewage works. Essentially the same material as covered by reference No. 599. Air consumption was from 0.624 to 1.108 cu. ft. per gallon of sewage treated. Suggestions for a new plant are given.

603 The New Orleans Meeting, Am. Inst. Chem. Engrs. ANON. *Chem. & Met. Engrg.* 23, 1198-1202. A brief review of the papers presented including that on activated sludge by DR. E. BARTOW. In the author's opinion the greatest problem requiring solution appears to be an economical method of drying the sludge. Experiments at Milwaukee are referred to.

604 Nitrogen in sewage. ANON. *Chem. Age* (Lond.) 3, 709. Refers to the activated sludge fertilizer experiments at Harpenden. According to the report of the Developments Commission, the total amount of N contained in

the sewage of the United Kingdom is estimated at 230,000 tons, equivalent to 1,150,000 tons of sulphate of ammonia, most of which is wasted. With the general adoption of the activated sludge process considerable would be added to the supply of organic manures.

605 Test of Trent activated sludge devices at Pasadena. R. V. ORBISON. *Eng. News-Record* 85, 1286-8. The Trent device consists of revolving perforated arms of the Barker mill type, submerged in the aerating tanks. The experiments were carried on for six months and the general conclusion reached was that it was not as satisfactory as the old aeration method through filtros plates, it requiring twice the time and costing more to operate. Removal of suspended solids and bacteria, reduction of O consumed and stability, were all inferior to the old method. Plant consisted of four tanks designed to treat 50,000 g. p. d.

606 The conservation of nitrogen with special reference to activated sludge. G. J. FOWLER. *Jour. Ind. Inst. Science.* 3, (Part VIII) 227-79. (December, 1920.) An elaborate and detailed account of the sources, production and consumption of N, with particular reference to the possibility of recovering the greater portion of the N in sewage. The activated sludge and other methods of sewage treatment are described, the following data indicating the extent to which first method is considered. Activated sludge as manure, giving a summary of the results obtained and conclusions reached by several workers. The nitrogen in activated sludge, showing its several combinations as revealed by the experiments at the Frankland laboratory, Univ. of Manchester, by the experiments of MRS. MUMFORD, the Rothamsted experiments and those at the Indian Inst. of Science under the author's direction, the latter pointing to a fixation of atmospheric N by activated sludge and the suggestion made that by the proper choice of carbohydrate food, the necessary symbiotic organisms, and proper temperature control, that it may be possible to build up a special activated sludge which will fix N in quantity and at such a rate that it might compete with commercial processes. Paragraphs are devoted to "The selection of plants responsive to activated sludge"; "Effect of activated sludge on special Indian crops"; "Condition of availability of nitrogen in activated sludge"; "Intensive cultivation by means of activated sludge"; and "The drying of activated sludge for transport." In the latter connection, electroendosmose is suggested as an attractive line of attack. "The treatment of concentrated latrine sewage by activated sludge" with reference to conditions in Shanghai, China, is considered and several illustrations of present methods of nightsoil collection given. A brief summary of the literature concludes the article.

INDEX OF LOCATIONS WITH SOME PLANT DATA.

Aintree, Eng.—1916 on. Regular plant at National Filling Factory. Population 2,000. Porous tile air diffusers. Ref. 505.

Alhambra, Calif.—See Pasadena.

America.—Ref. 60, 85, 180, 328, 380.

Argo, Ill.—See Chicago, Sanitary District.

Austin, Tex.—1918. Experimental plant at the Univ. of Texas in conjunction with the city. Ref. 394.

Baltimore, Md.—1915-6. Municipal experimental plant. City sewage. Aerating tank capacity 200,000 gallons. Continuous flow plan. Disks of FILTROS, carborundum and perforated brass tried as air diffusers. Ref. 36, 38, 42, 47, 50, 53, 55, 82, 134, 143, 157, 170, 176, 180, 195, 223, 228, 292.

Bangalore, India.—1917. Experimental plant at the Indian Institute of Science, for research purposes. Ref. 440, 606.

Bingley, Eng.—1918 on. Municipal experimental plant. City sewage. Treatment capacity 300,000 g. p. d. on the fill and draw plan. Porous tile air diffusers. Ref. 481.

Blackpole, Eng.—1917. Regular plant at Government cartridge factory. Population 4,000. Porous tile air diffusers. Ref. 505.

Boonton, N. J.—1918. Plant proposed and plans approved. Ref. 313, 315, 403.

Brampton, Ont., Can.—1918. Regular municipal plant. City sewage. FILTROS air diffusers. Ref. 532, 548.

Brockton, Mass.—1915 on. Municipal experimental plant. City sewage. Aerating tank capacity approx. 4,500 gallons, fill and draw plan. 1916, continuous flow plan. 1917, plans preparing for a 3 million g. p. d. plant. 1918, postponed on account of the war. Ref. 159, 260, 292, 316, 421.

Brooklyn, N. Y.—1915 on. Municipal experimental plant. City sewage. Aerating tank capacity on fill and draw plan, 16,000 gal., on continuous flow plan, 900 gal. Air diffusion through perforated pipes, carborundum and other porous material. Ref. 7, 31, 61, 88, 103, 104, 109, 115, 130, 143, 156, 170, 180, 195, 206, 241, 292, 503.

Burnley, Eng.—1920. Plant proposed. Ref. 511.

Bury, Eng.—1920. Plant referred to in Ref. 507.

Canada.—Ref. 54.

Champaign, Ill.—1915 on. Municipal experimental plant in connection with the Ill. State Water Survey. (See Urbana.) Aerating tank capacapacity 36,000 gal. City sewage. Continuous flow plan. FILTROS air diffusers. 1920, a complete experimental plant of 100,000 g. p. d. proposed. Ref. 195, 246, 310, 556.

Chicago, Ill.—Armour & Co., stockyards. 1915 on. Private experimental plant. Packinghouse wastes. Aerating tank capacity 30,000 gal. Continuous flow plan. Perforated pipe air diffusers. Ref. 86, 90, 128, 173, 175, 195, 206, 292.

Chicago, Ill.—Sanit. Dist. Argo, Ill. 1920 on. Experimental plant. Corn products refining wastes. Continuous flow plan. Treatment capacity about 50,000 g. p. d. FILTROS air diffusers. Other methods being tried. (Private advice.) Ref. 541, 589.

Chicago, Ill.—Sanit. Dist. Calumet region. 1920 on. Regular plant under construction. Aerating capacity 3.5 million g. p. d. Continuous flow plan. FILTROS air diffusers. (Private advice.) Ref. 541.

Chicago, Ill.—Sanit. Dist. DesPlaines river plant. 1920 on. Regular and semi-experimental plant under construction. Domestic sewage. Continuous flow plan. Aerating capacity 4.5 million g. p. d. FILTROS air diffusers. Ref. 401, 541, 598.

Chicago, Ill.—Sanit. Dist. Griess-Pfleger testing station. 1920 on. Experimental plant. Tannery wastes. Continuous flow plan. Aerating capacity 100,000 g. p. d. FILTROS air diffusers. (Private advice.) Ref. 541.

Chicago, Ill.—Sanit. Dist. Stockyards. 1915 on. Experimental plant. Mixed packinghouse (75%) and domestic (25%) sewage. Aerating tanks, four of 35,000 gal. capacity each . Continuous flow plan. Perforated pipes and FILTROS air diffusers used. 1917, 50 million g. p. d. plant recommended, FILTROS air diffusers specified. Ref. 90, 97, 103, 123, 128, 134, 142, 143, 147, 148, 170, 195, 223, 226, 262, 271, 286, 317, 318, 322, 323, 326, 327, 337, 345, 365, 366, 380, 394, 408, 476, 478, 482, 484, 501, 513, 533, 541, 569, 589, 601.

Chicago, Ill.—Sanit. Dist. 39th St. Center. 1916. Plant considered. Ref. 214.

Chicago, Ill.—Swift & Co., Morris & Co., Sulzberger & Sons Co. 1915. Private experimental plants. Packinghouse wastes. Ref. 86, 90.

Cleveland, O.—1915 on. Municipal experimental plant. City sewage. Designed to treat 1 million g. p. d. Continuous flow plan. FILTROS air diffusers. Ref. 69, 106, 134, 137, 143, 170, 195, 219, 223, 241, 305, 306, 325, 356, 357, 359, 369, 390, 394, 430, 431, 576.

Coleman, Tex.—1919. Regular plant and septic tanks treat entire sewage of city. Ref. 493.

Columbus, O.—1920. Small experimental plant. City sewage. FILTROS air diffusers. (Private advice).

Decatur, Ill.—1917. Municipal experimental plant. City sewage. Ref. 241, 577.

Decatur, Ill.—1919. Private experimental plant. Starch factory wastes. FILTROS air diffusers. (Private advice).

East Walpole, Mass.—1916. Private experimental plant. Paper mill wastes. (See *Jour. Ind. Eng. Chem.* 8, 648.)

Edmonton, Alberta, Can.—1915 on. Part of regular municipal plant. City sewage. Six aerating tanks of about 25,000 gal. capacity each. Fill and draw plan. Perforated pipe diffusers. Ref. 195, 213, 266.

El Dorado, Kans.—1920. Municipal experimental plant under construction. FILTROS air diffusers. (Private advice).

England—Ref. 79, 178, 195, 242, 332, 348, 380, 507, 534.

Escanaba, Mich.—1917. Regular municipal plant. City sewage. Aerating capacity, approx. 1 million g. p. d. Continuous flow plan. FILTROS air diffusers. Ref. 253.

Folsom, Calif.—1917. Regular plant. Institutional sewage. Perforated pipe air diffusers. Ref. 358, 567.

Fort Worth, Tex.—1916-7. Armour & Co. Private experimental plant. Packinghouse wastes. Aerating capacity about 86,400 g. p. d. Perforated pipes and FILTROS air diffusers used. Ref. 195, 276, 291, 318, 326, 327, 345, 366, 380, 394, 493.

Fremont, Mich.—1919. Private experimental plant. Tannery wastes. FILTROS air diffusers. (Private advice).

Gainesville, Tex.—1919. Ref. 493.

Gastonia, N. C.—1920. Municipal plant. City sewage. FILTROS air diffusers. (Private advice).

Glasgow, Scot.—1920. Experimental plant to be recommended. Ref. 522.

Grand Rapids, Mich.—1918. Private experimental plant. Tannery wastes. FILTROS air diffusers. (Private advice).

Harpenden, Eng.—1918. Experimental plant for H. M. Bd. of Agr. for producing activated sludge for fertilizer tests. Ref. 452, 505, 507, 508, 553, 604.

Hermosa Beach, Calif.—1916. Regular municipal plant proposed. City sewage. Treatment capacity, 400,000 g. p. d. Mechanical agitation. Ref. 179, 208, 567.

Houston, Tex.—1915 on. Municipal experimental plant, later, two regular pants. City sewage. Total treatment capacity about 15 million g. p. d. Continuous flow plan. FILTROS air diffusers. Ref. 73, 114, 134, 140, 146, 170, 195, 236, 251, 292, 296, 366, 392, 394, 414, 442, 493, 496, 497, 510, 513, 536, 589, 597.

India.—Ref. 184, 281, 348, 440.

Indianapolis, Ind.—1917. Activated sludge process considered but rejected as unsuited to local conditions. Ref. 346, 347, 400.

Jersey City, N. J.—See Boonton, N. J.

Kansas.—Ref. 352.

Lawrence, Mass.—1912 on. State experiment station. Numerous studies: various size tanks. Perforated brass disks and FILTROS air diffusers tried. Ref. 1, 4, 8, 25, 30, 38, 40, 72, 101, 125, 162, 195, 206, 233, 292, 332, 362, 409, 446, 519, 520, 524, 529, 534, 549.

Lima, Ohio.—1916. Activated sludge plant recommended. Ref. 164.

Lincoln, Eng.—1917. Experimental plant referred to in ref. 366.

London, Eng.—1916 on. Laboratory experiments and Municipal experimental plant. Ref. 163, 521, 531, 571, 601.

Manchester, Eng.—Bagulay Sanatorium. 1914. First regular plant in England. Fill and draw plan. Capacity 20,000 g. p. d. Porous tile diffusers. Ref. 91, 111.

Manchester, Eng.—Davyhulme works. 1913 on. Municipal experimental plant. City sewage. Numerous experiments. 1918-9. 1 million g. p. d. plant under construction. Continuous flow plan. Ref. 8, 26, 38, 120, 134, 372, 397, 449, 452, 485, 499, 505, 508, 525, 594.

Manchester, Eng.—Withington works. 1913 on. Municipal experimental plant. City sewage. Numerous experiments. 1918. Continuous flow tanks treating up to 375,000 g. p. d. Ref. 199, 244, 366, 379, 381, 397, 417, 420, 425, 449, 485, 499, 505, 507, 514, 525, 527.

Manchester, Eng.—Works not stated. Ref. 9, 12, 24, 35, 36, 40, 64, 71, 72, 103, 106, 125, 152, 162, 198, 224, 232, 234, 292, 296, 373, 442, 479, 519, 524, 529, 600.

Matawan, N. J.—1916. Plans for plant approved. Ref. 171.

Maynard, Mass.—1916. Private experimental plant. Woolen mill wastes. (*See Jour. Ind. Eng. Chem.* 8, 648.)

Milwaukee, Wis.—1914 on. Municipal experimental plant. City sewage. numerous experiments with aerating tanks of various sizes on both fill and draw and continuous flow plans. Perforated pipes, wood blocks and FILTROS air diffusers tried. 1920. 85 million g. p. d. regular plant under construction. FILTROS air diffusers specified. Ref. 38, 44, 58, 66, 70, 72, 75, 76, 81, 87, 88, 89, 91, 100, 103, 106, 112, 116, 117, 121, 122, 125, 126, 134, 136, 138, 141, 143, 145, 147, 150, 151, 153, 170, 180, 188, 191, 193, 195, 197, 205, 206, 207, 223, 227, 229, 232, 234, 240, 245, 280, 288, 292, 296, 328, 330, 332, 333, 353, 356, 364, 365, 366, 370, 377, 389, 394, 398, 408, 417, 442, 453, 464, 471, 491, 500, 512, 513, 526, 550, 554, 555, 584, 589, 590, 601, 603.

Milwaukee, Wis.—1915. Private experimental plant. Tannery wastes. FILTROS air diffusers. (Private advice). Ref. 289.

Moreton, Eng.—(Near Worcester). 191 ? Regular plant for Admiralty Airship Station. Population, 400. Porous tile diffusers. Ref. 301, 452, 505.

Moscow, Russia.—1917. Experimental plant. Fill and draw plan. Capacity 135,000 g. p. d. Perforated pipe diffusers. (Noted in K. W. & P. Book. Ref. 506).

Mt. Vernon, N. Y.—1919. Experimental plant, privately conducted. City sewage. Treatment capacity, 45,000 g. p. d. Mechanical agitation and FILTROS air diffusers. Ref. 477, 579, 581.

New Britain, Conn.—1920. Municipal experimental plant. City sewage. FILTROS air diffusers. (Private advice).

New Haven, Conn.—1917 on. Experiment station. City sewage. Treatment capacity, 17,000 g. p. d. Continuous flow plan. FILTROS air diffusers used. Ref. 329, 338, 354, 426, 432, 448, 462, 592.

North Toronto, Can.—Ref. 248, 272.

Norwood, Mass.—1916. Private experimental plant. Tannery and wool scouring wastes. Aerating tank, 1,000 gal. capacity. Fill and draw plan. FILTROS air diffusers. Ref. 203, 292.

Paris, France.—1917. Laboratory experiments. Ref. 340.

Paris, Texas.—1916. Regular municipal plant. City sewage. FILTROS air diffusers used. Ref. 493.

Pasadena, Calif.—1916 on. Experimental municipal plant. City sewage of South Pasadena and Alhambra included. Treatment capacity 50,000 g. p. d. FILTROS air diffusers. 1919-20. Trent agitating devices tried. Ref. 132, 210, 250, 257, 331, 349, 374, 572, 605.

Peterboro, Ont., Can.—1920. Activated sludge plant considered. Ref. 585.

Pittsfield, Mass.—1920. Private experimental plant. Industrial wastes. FILTROS air diffusers. (Private advice).

Port Colborne, Ont., Can.—1917. Private regular plant. Metallurgical and domestic wastes. FILTROS air diffusers. (Private advice).

Port Colborne, Ont., Can.—1920. Regular municipal plant considered. Ref. 575.

Providence, R. I.—1917. Municipal experimental plant. City sewage. FILTROS air diffusers. (Private advice).

Quanah, Texas.—1918. Regular municipal plant. Ref. 493.

Reading, Eng.—1919. Activated sludge process adopted to treat entire city sewage. Ref. 461, 472, 508, 557, 583, 586, 591, 596.

Regina, Sask., Can.—1915. Municipal experimental plant. City sewage. Aerating tanks, two of 577.8 Imp. gallons each. Fill and draw plan. Air diffused through perforated pipes covered with canvas. Ref. 38, 54, 134, 195, 230, 249.

Sakchi, India.—191? Plant considered to care for future population of 150,000. Ref. 281, 440.

Salford, Eng.—1914 on. Municipal experimental plant. City sewage. Treatment capacity, 75,000 gal. in 21 hours on fill and draw plan; 60,000 g. p. d. on continuous flow plan. Perforated pipe air diffusers. 1919. Adoption recommended for regular plant. Ref. 22, 24, 26, 29, 36, 38, 62, 64, 93, 95, 102, 106, 133, 134, 232, 240, 244, 292, 296, 366, 372, 417, 475.

San Angelo, Tex.—1919. Regular municipal plant. City sewage. Treatment capacity, 400,000 g. p. d. Perforated pipe air diffusers. Ref. 493, 518.

San Marcos, Tex.—1916. Regular municipal plant; beieved to be the first in the U. S. treating the entire sewage of a city. Treatment capacity, 150,000 g. p. d. FILTROS air diffusers. Ref. 195, 197, 252, 259, 394, 493.

Sarisbury Court, Eng.—(Near Southampton). 1918. Hospital installation for 200 patients and staff. Porous tile air diffusers. Ref. 452, 486, 505.

Shanghai, China.—1919. Experimental municipal plant recommended. FILTROS air diffusers. Ref. 436, 474, 578, 606.

Sheffield, Eng.—1915 on. Experimental municipal plant. City sewage. Numerous experiments. 1919: aerating tanks treating 110,000 g. p. d. using mechanical agitation. 1920: 1 million g. p. d. plant building. Ref. 167, 168, 215, 232, 328, 366, 458, 468, 469, 479, 481, 502, 511, 514, 529, 553, 578.

Sherman, Tex.—1918. Regular municipal plant. City sewage. FILTROS air diffusers. Ref. 493.

Shieldhall, Scot.—See Glasgow.

South Pasadena, Calif.—See Pasadena.

St. Albans, Eng.—1918. Experimental municipal plant. City sewage. Treatment capacity 30,000 g. p. d. Continuous flow plan. Porous tile diffusers. Ref. 422, 442, 452.

Stamford, Eng.—1915 on. Experimental municipal plant. City sewage. Treating 100,000 g. p. d. Porous tile air diffusers. Ref. 91, 111, 134, 232, 240, 296, 366, 381, 417, 505.

Sydney, Australia.—1916 on. Experimental municipal plant. Aerating tanks, 500 and 10,000 gal. capacity. Fill and draw plan. Perforated pipes covered with broken stone for air diffusion. 1919-20. Treating 900,000 g. p. d. Ref. 320, 568, 588.

Syracuse, N. Y.—1917 on. Municipal experimental plant. City sewage. Aerating tank approximately 3,000 gal. capacity. Continuous flow plan. Perforated pipe air diffusers. Ref. 363, 378, 484.

Texas.—Ref. 447, 457, 465, 493, 504.

Toronto, Can.—1920. Small experimental plant. FILTROS air diffusers. (Private advice).

Tunstall, Eng.—1918. Municipal experimental plant. City sewage. Treating 300,000 g. p. d. on continuous flow plan. Porous tile air diffusers. Ref. 452, 489, 505, 507, 562, 593, 595, 599, 602.

United States.—Ref. 36, 66, 178, 348, 420.

Urbana, Ill.—1914 on. Experiment station Ill. State Water Survey at the Univ. of Ill. Numerous investigations. Believed to be the first exclusive activated sludge plant in the U. S. First to use FILTROS air diffusers. Ref. 35, 38, 43, 72, 88, 113, 116, 121, 135, 170, 195, 210, 232, 292, 296, 302, 310, 394, 408, 556, 589.

Wakefield, Eng.—1915 on. Municpial experimental plant. City sewage. Capacity of aerating tank approximately 13,500 gal. on fill and draw plan. Porous tile air diffusers. Ref. 20, 38, 63.

Wimbledon, Eng.—1916. Aeration experiments contemplated, using atomizers. Ref. 107, 108.

Woodstock, Ont., Can.—1920. Regular municipal plant building. FILTROS air diffusers. (Private advice).

Worcester, Eng.—1915 on. Municipal experimental plant. City sewage. Numerous experiments. 1916: treating 750,000 g. p. d. on continuous flow plan. Porous tile air diffusers. Ref. 91, 102, 111, 134, 172, 174, 232, 240, 242, 247, 278, 279, 282, 283, 284, 293, 295, 296, 298, 299, 300, 360, 366, 379, 397, 415, 417, 442, 452, 463, 470, 505, 601.

Worcester, Mass.—1917-8. Municipal experimental plant. City sewage. Treatment capacity, 100,000 g. p. d. Continuous flow plan. FILTROS air diffusers. Ref. 223, 258, 260, 351, 437, 487, 540.

York Township, Ont., Can.—1919. Activated sludge process considered. Ref. 498.

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General Filtration Company, Inc.
General Offices - Rochester, N. Y.
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